Management of Confined Disposal Facilities

GEOTECHNICAL APPENDIX D2

DISPOSAL FACILITY #3
LABORATORY TEST RESULTS
AND CAPACITY ANALYSIS
FIELD DEMONSTRATION

U.S. Army Engineer District, Buffalo • 1776 Niagara Street • Buffalo New York 14207

TOLEDO CONFINED DISPOSAL FACILITY

GEOTECHNICAL APPENDIX
DISPOSAL FACILITY CAPACITY ANALYSIS

ATTACHMENT ~~A~~1
LABORATORY TEST RESULTS

TOLEDO CONFINED DISPOSAL FACILITY

GEOTECHNICAL APPENDIX
DISPOSAL FACILITY CAPACITY ANALYSIS

ATTACHMENT 1
LABORATORY TEST RESULTS

TABLE OF CONTENTS

TOLEDO CONFINED DISPOSAL FACILITY

GEOTECHNICAL APPENDIX
DISPOSAL FACILITY CAPACITY ANALYSIS

ATTACHMENT #1
Maumee River Sediment Particle Size Analysis
Floyd-Brown Associates

MASTER

Analysis of Sediment
from Toledo Harbor -
Maumee River
1983
Toledo, Ohio

Contract #DACW49-83-D-0006
Technical Report #G0130-05

LLOYD
BROWNE
ASSOCIATES
LIMITED

AQUA TECH

ENVIRONMENTAL
CONSULTANTS INC.

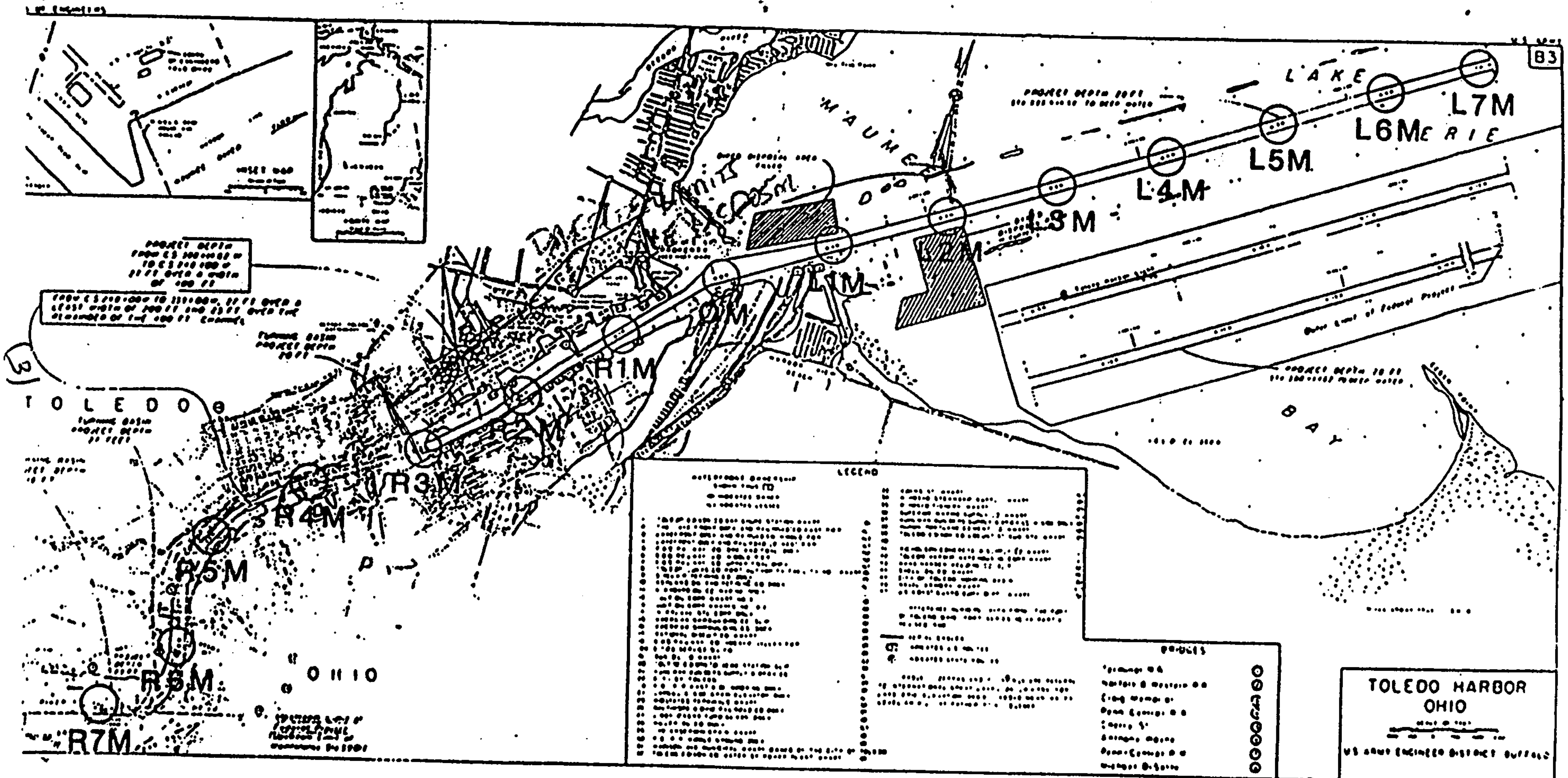

Figure 1. Toledo Harbor/Maumee River Sampling Locations.

Table IX. Particle Size Analysis of Sediments Collected from Toledo Harbor/Maumee River on October 31, 1983.

Lab No.	Identif. (Site No.)	Percentage of Soil per Particle Size Retained #8	Retained #16	Retained #30	Retained #50	Retained #100	Retained #200	Passe[d] #200
3072-83	L-7-M	0.8	1.2	5.2	14.0	14.8	12.8	51.2
3072-83R	L-7-M Replicate	0.0	1.5	5.1	12.3	13.8	13.8	53.5
3073-83	L-6-M	0.7	0.5	0.2	0.0	1.2	0.7	96.7
3074-83	L-5-M	0.4	1.6	4.4	11.1	12.8	14.0	55.7
3075-83	L-4-M	1.3	1.5	1.2	1.7	3.3	7.2	83.8
3076-83	L-3-M	0.0	0.0	0.0	0.0	0.0	0.0	100.0
3077-83	L-2-M	0.1	0.3	0.3	3.2	11.8	10.9	73.4
3078-83	L-1-M	0.0	0.0	0.0	0.0	0.0	0.0	100.0
3079-83	0-M	0.0	0.0	0.0	0.0	0.9	0.8	98.3
3080-83	R-1-M	0.0	0.2	0.3	1.0	5.0	20.8	72.7
3081-83	R-2-M	0.0	0.0	0.0	0.0	1.2	0.0	98.8
3081-83R	R-2-M Replicate	0.0	0.0	0.0	0.0	0.9	0.2	98.9
3082-83	R-3-M	0.0	0.0	0.0	0.0	0.0	0.0	100.0
3083-83	R-4-M	3.8	4.4	5.7	5.8	1.4	0.5	78.4
3084-83	R-5-M	0.0	0.2	0.8	5.8	14.7	17.9	60.6
3085-83	R-6-M	0.0	0.3	0.9	10.0	19.4	15.9	53.5
3086-83	R-7-M	0.0	0.0	0.0	0.6	0.4	0.2	98.8

TOLEDO CONFINED DISPOSAL FACILITY

GEOTECHNICAL APPENDIX
DISPOSAL FACILITY CAPACITY ANALYSIS

ATTACHMENT ~~A~~W1
Maumee River Sediment Particle Size Analysis

Joseph V. DePinto, Thomas C. Young and Lois Terry
Dept. of Civil and Environmental Engineering
Clarkson University

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EFFECT OF OPEN-LAKE DISPOSAL OF TOLEDO HARBOR DREDGED MATERIAL ON BIOAVAILABLE PHOSPHORUS IN LAKE ERIE WESTERN BASIN

by

Joseph V. DePinto, Thomas C. Young and Lois Terry
Dept. of Civil and Environmental Engineering
Clarkson University
Potsdam, NY 13676
Phone: (315) 268-6532 or -4430

Submitted to: Department of the Army
U. S. Army Engineer District, Buffalo
1776 Niagara St.
Buffalo, NY 14207

September 30, 1986

Table 3. Physical Characteristics of Toledo Harbor Area Bottom Sediment Samples

Site	Median Particle Diameter (µm)*	FRACTIONAL SIZE CLASSIFICATION Clay (0.2-4 µm)	Silt (4-62 µm)	Sand (62 µm-2 mm)	Bulk Denisty (g dry/ml)	Moisture Content Percent (w/w) ml/g soil water
1	5	46 $\bar{x}$ = 38	26 $\bar{x}$ = 34	28 $\bar{x}$ = 28	0.45	43.4
2	9	40	33	27	0.55	41.7
3	46	27	43	30	0.70	37.3
4	260	<12	<12	88	1.25	22.9
5	25	31	49	20	0.68	35.9
6	26	26	49	25	0.77	34.5
7	64	18	28	54	0.56	40.8
8	13	32	53	15	0.43	45.8
9	11	33	37	30	0.45	45.8
10	68	15	49	64	0.56	41.2
11	60	16	52	68	0.73	35.7
12	>100	5	5	90	0.76	35.0

*Defined as diameter for which 50% of mass is made up of smaller particles.

TOLEDO CONFINED DISPOSAL FACILITY

GEOTECHNICAL APPENDIX
DISPOSAL FACILITY CAPACITY ANALYSIS

ATTACHMENT A1
Maumee River Sediment Particle Size Analysis
Prepared for T.P, Associates, Inc.

The Analyses of Sediments
from Toledo Harbor
Contract #DACW 49-87-D-0002
Delivery #0012
Technical Report #I0175-12
June 1988

Prepared for:

Mr. Willaim Pfeiffer
T. P. Associates International, Inc.
17875 Cherokee
Harpster, OH 43323

Approved by:
Michael H. Davis

Michael H. Davis, Ph.D.
Quality Assurance Officer

Table III. Hydrometer Testing Results - Toledo Harbor (ASTM Method D 422-63).

Gs=2.6

LAB NO.	IDENT.	WET WT. (G)	% SOLIDS	DRY WT. (G)	e	HYDROMETER DENSITY READINGS 2 (MIN)	5 (MIN)	15 (MIN)	30 (MIN)	60 (MIN)	240 (MIN)	1440 (MIN)
4353-88	D-4	100.3	48.3	48.4	2.8	1.028	1.028	1.023	1.020	1.019	1.016	1.014
4354-88	D-3	100.1	33.2	33.2	6.3	1.023	1.021	1.021	1.019	1.018	1.015	1.012
4355-88	D-2	100.2	31.0	31.1	5.9	1.024	1.022	1.020	1.020	1.017	1.014	1.012
4356-88	D-1	100.2	42.2	42.3	3.6	1.024	1.022	1.020	1.018	1.016	1.014	1.012
4357-88	L-16-M	100.1	59.4	59.5	1.8	1.019	1.017	1.017	1.105	1.013	1.011	1.010
4357-88R	L-16-M Rpt.	100.0	59.4	59.4	1.8	1.018	1.017	1.016	1.015	1.013	1.011	1.010
4358-88	L-15-M	100.2	38.5	38.6	4.2	1.021	1.020	1.018	1.017	1.015	1.012	1.011
4359-88	L-14-M	100.3	42.2	42.3	3.6	1.020	1.019	1.018	1.016	1.014	1.013	1.011
4360-88	L-13-M	99.9	54.0	53.9	2.3	1.019	1.017	1.016	1.016	1.014	1.012	1.010
4361-88	L-12-M	100.1	35.0	35.0	4.9	1.019	1.018	1.016	1.015	1.014	1.012	1.010
4362-88	L-11-M	100.1	36.3	36.3	4.7	1.020	1.017	1.017	1.016	1.014	1.012	1.011
4363-88	L-10-M	99.8	30.0	29.9	6.2	1.019	1.018	1.016	1.015	1.014	1.012	1.011
4364-88	L-9-M	100.0	38.2	38.2	4.3	1.021	1.019	1.018	1.017	1.015	1.013	1.011
4365-88	L-8-M	100.0	48.8	48.8	2.8	1.023	1.022	1.021	1.018	1.016	1.014	1.012
4366-88	L-7-M	100.0	39.3	39.3	4.1	1.020	1.017	1.017	1.016	1.014	1.013	1.011
4367-88	L-6-M	100.0	41.7	41.7	3.7	1.022	1.020	1.018	1.016	1.016	1.014	1.012
4367-88R	L-6-M Rpt.	101.0	41.7	42.1	3.7	1.022	1.021	1.018	1.017	1.017	1.015	1.012
4368-88	L-5-M	99.7	46.2	46.1	3.1	1.025	1.023	1.018	1.019	1.017	1.014	1.012
4369-88	L-4-M	100.2	38.9	39.0	4.2	1.023	1.021	1.019	1.019	1.018	1.016	1.014
4370-88	L-3-M	101.4	43.3	43.9	3.5	1.022	1.020	1.017	1.017	1.016	1.013	1.011
4371-88	L-2-M	100.4	36.9	37.0	4.5	1.023	1.022	1.019	1.020	1.017	1.016	1.017
4372-88	L-1-M	99.9	36.6	36.6	4.6	1.025	1.024	1.022	1.022	1.020	1.018	1.015
4373-88	O-M	100.2	42.3	42.4	3.6	1.025	1.024	1.021	1.020	1.019	1.016	1.013
4373-88R	O-M Rpt.	99.4	42.3	42.0	3.4	1.026	1.025	1.023	1.022	1.020	1.018	1.015
4374-88	R-1-M	100.0	36.8	36.8	4.6	1.021	1.020	1.020	1.018	1.017	1.015	1.013
4375-88	R-2-M	99.5	37.0	36.8	4.5	1.027	1.026	1.024	1.023	1.021	1.019	1.015
4376-88	R-3-M	100.2	37.6	37.7	4.4	1.026	1.025	1.024	1.022	1.020	1.017	1.014
4377-88	R-4-M	100.9	54.7	55.2	2.2	1.025	1.024	1.022	1.021	1.019	1.016	1.014
4378-88	R-5-M	100.1	41.5	41.5	3.7	1.025	1.024	1.022	1.021	1.019	1.016	1.014
4379-88	R-6-M	100.3	46.6	46.7	3.0	1.022	1.022	1.021	1.019	1.018	1.016	1.014
4380-88	R-7-M	100.2	47.6	47.7	2.9	1.024	1.023	1.022	1.020	1.018	1.016	1.014
BLANK	—					1.004						

Ae=3.8

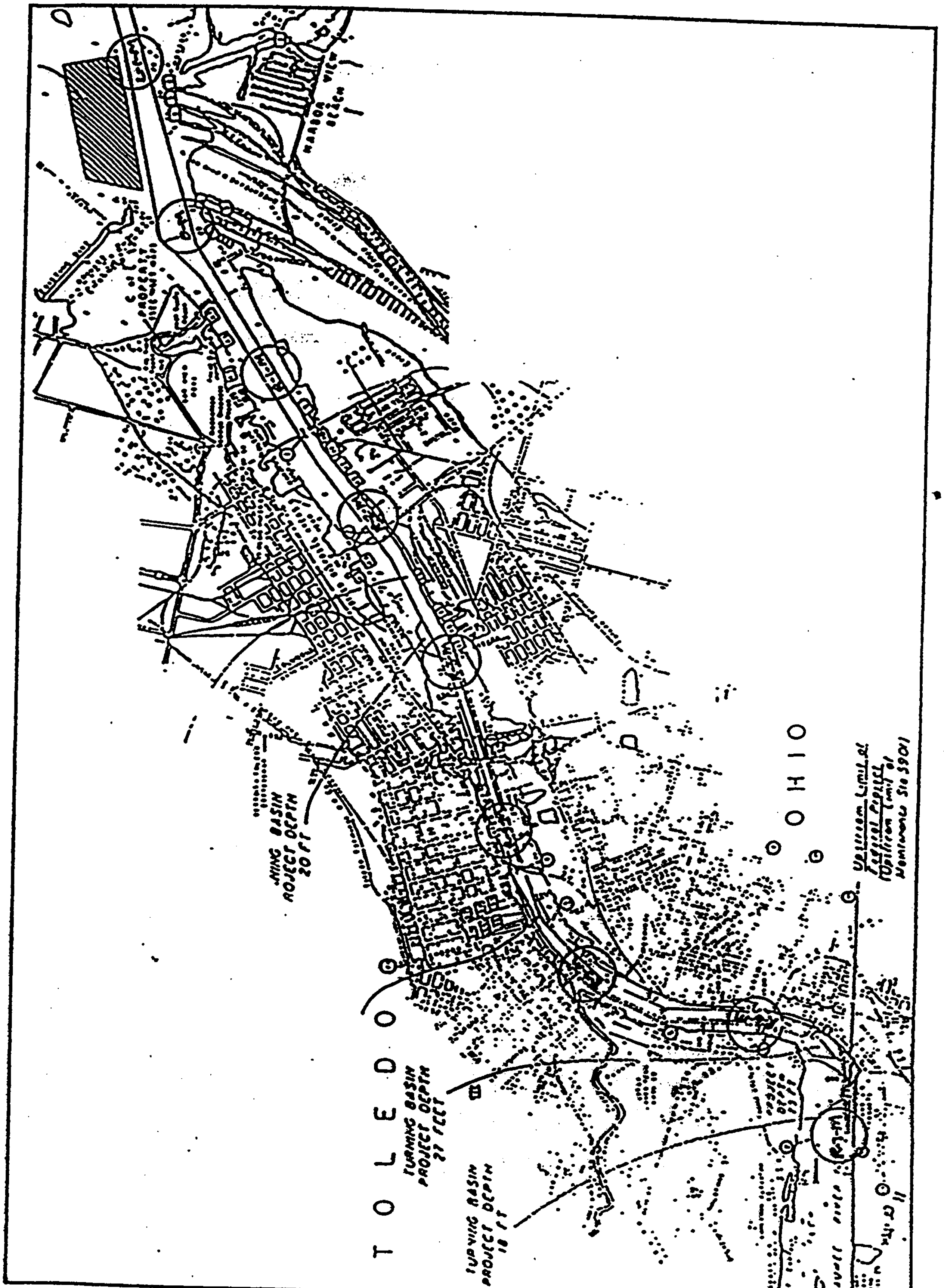


Figure 1. Toledo Harbor, Ohio sampling sites.

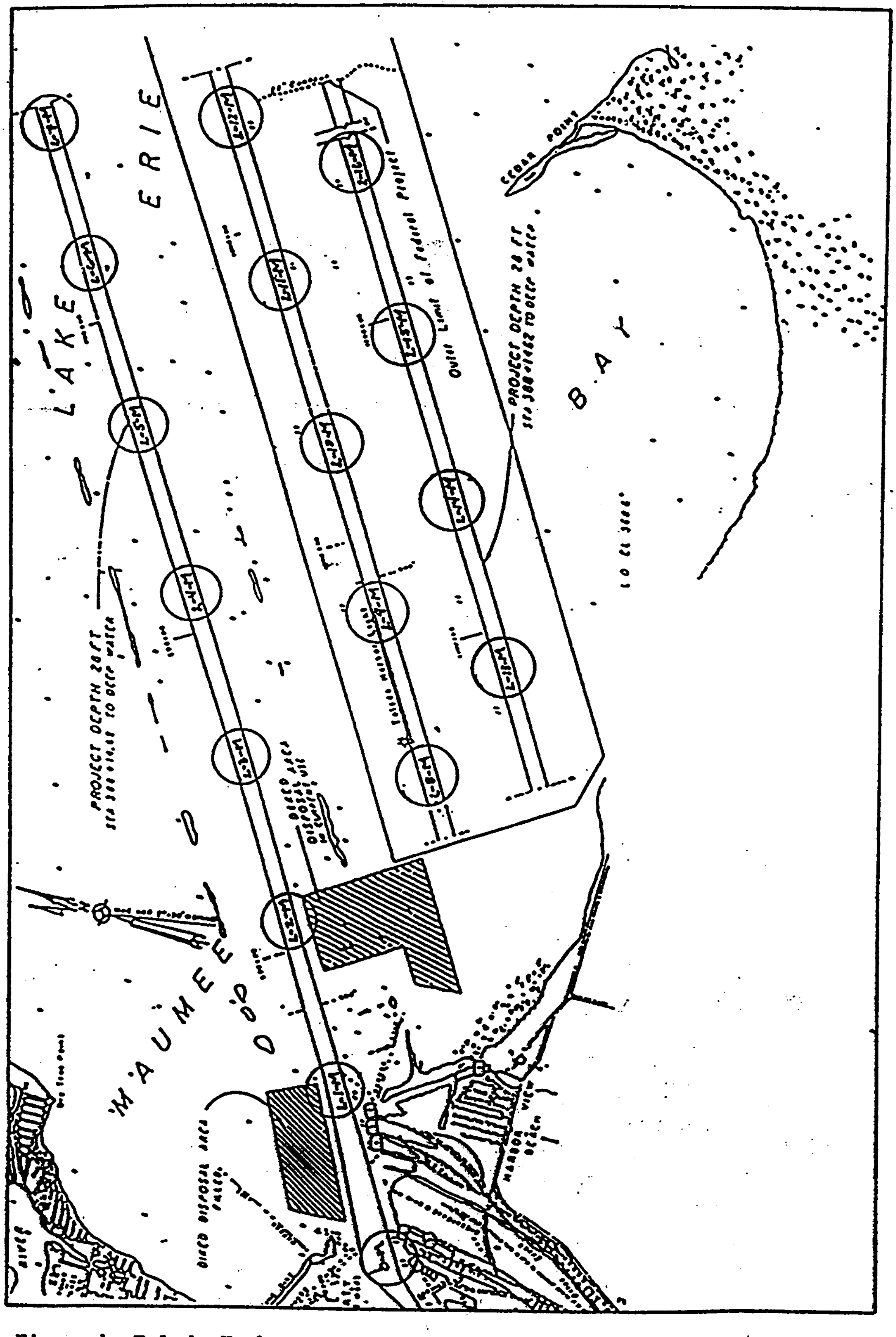
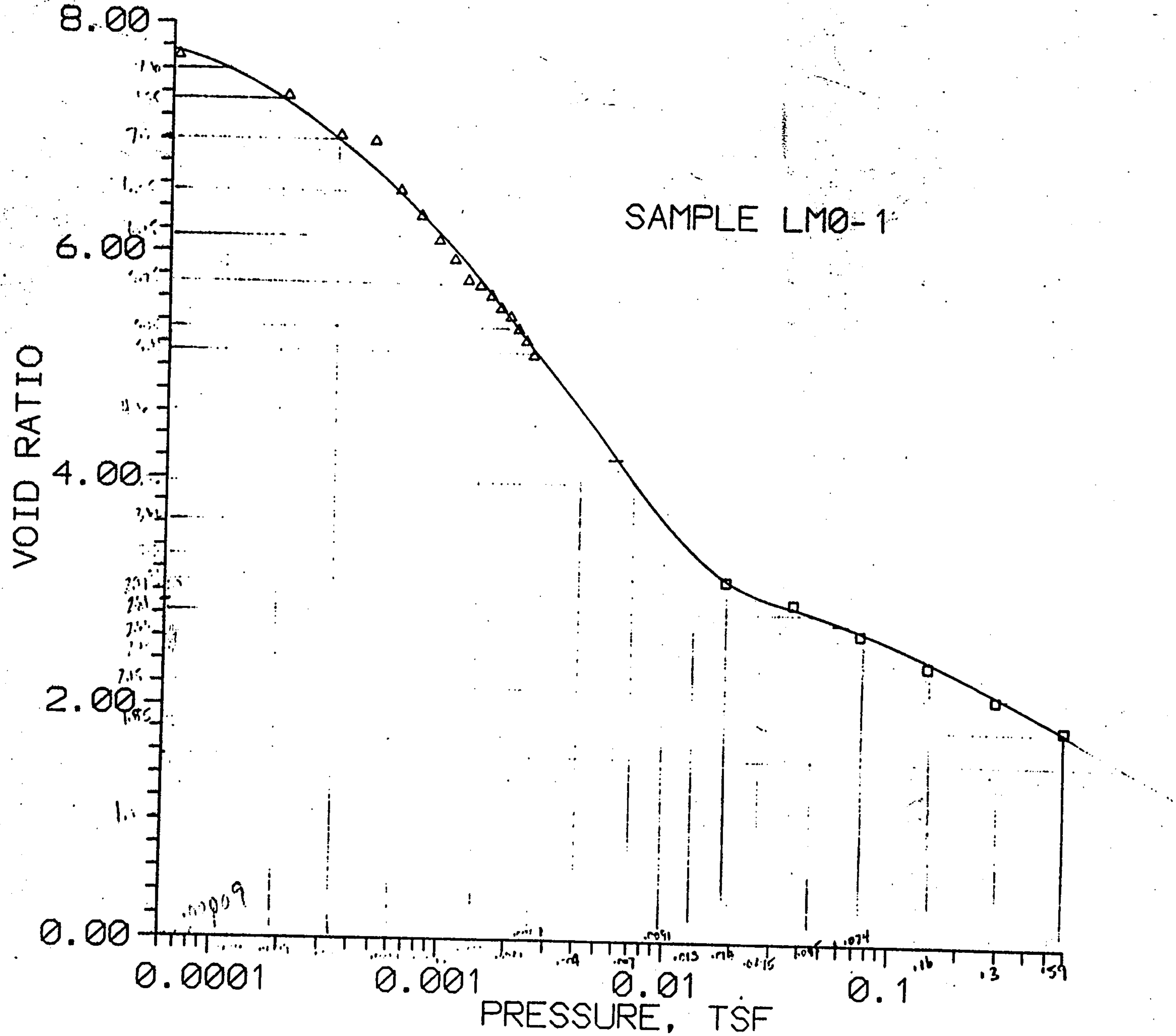


Figure 1. Toledo Harbor, Ohio sampling sites.
(cont'd)

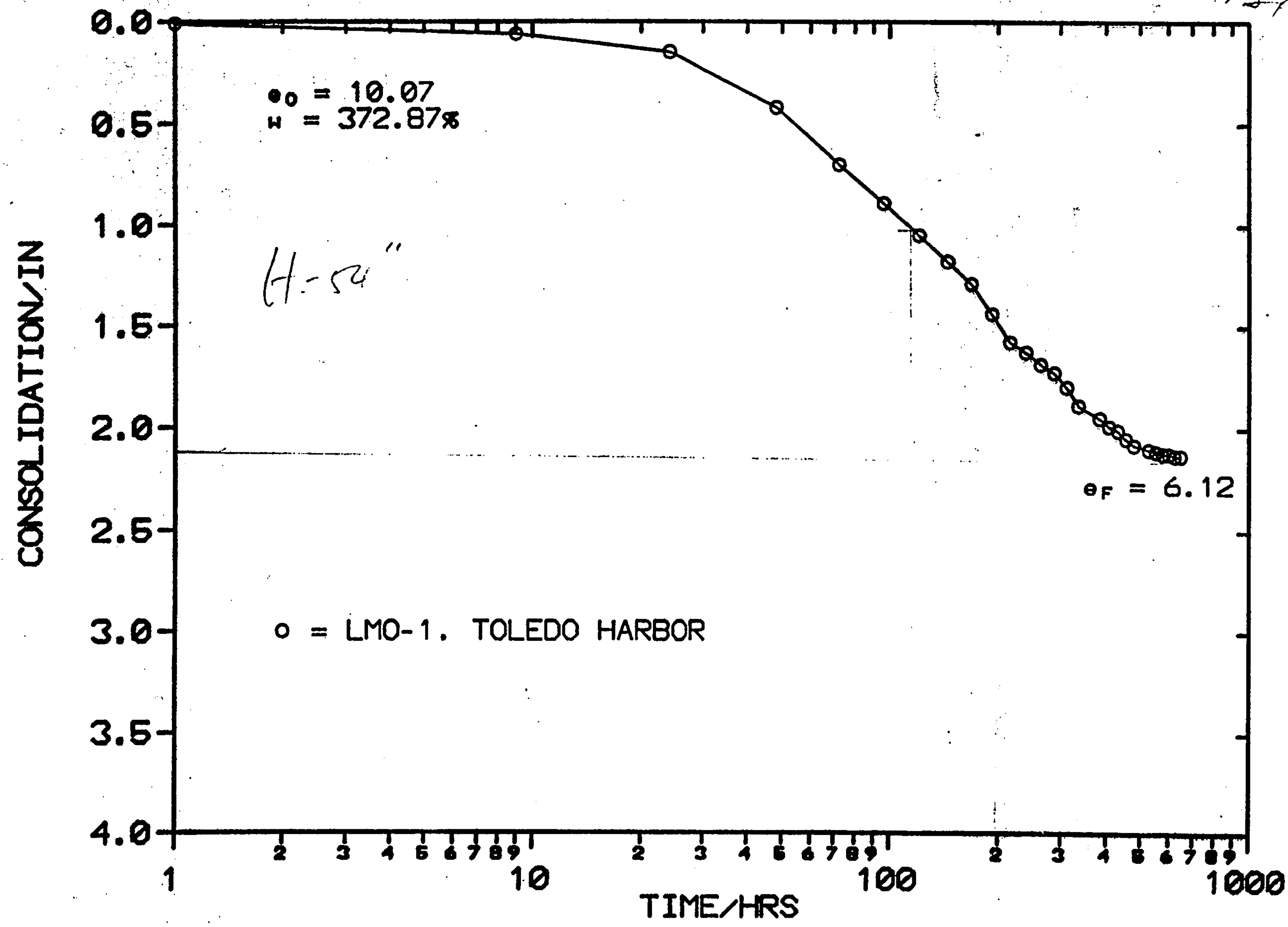
TOLEDO CONFINED DISPOSAL FACILITY

GEOTECHNICAL APPENDIX
DISPOSAL FACILITY CAPACITY ANALYSIS

ATTACHMENT A1
Maumee River Sediment Self Weight and Oedometer Consolidation Test Results
Preformed by Waterways Experiment Station
Vicksburg, Mississippi
for Buffalo District

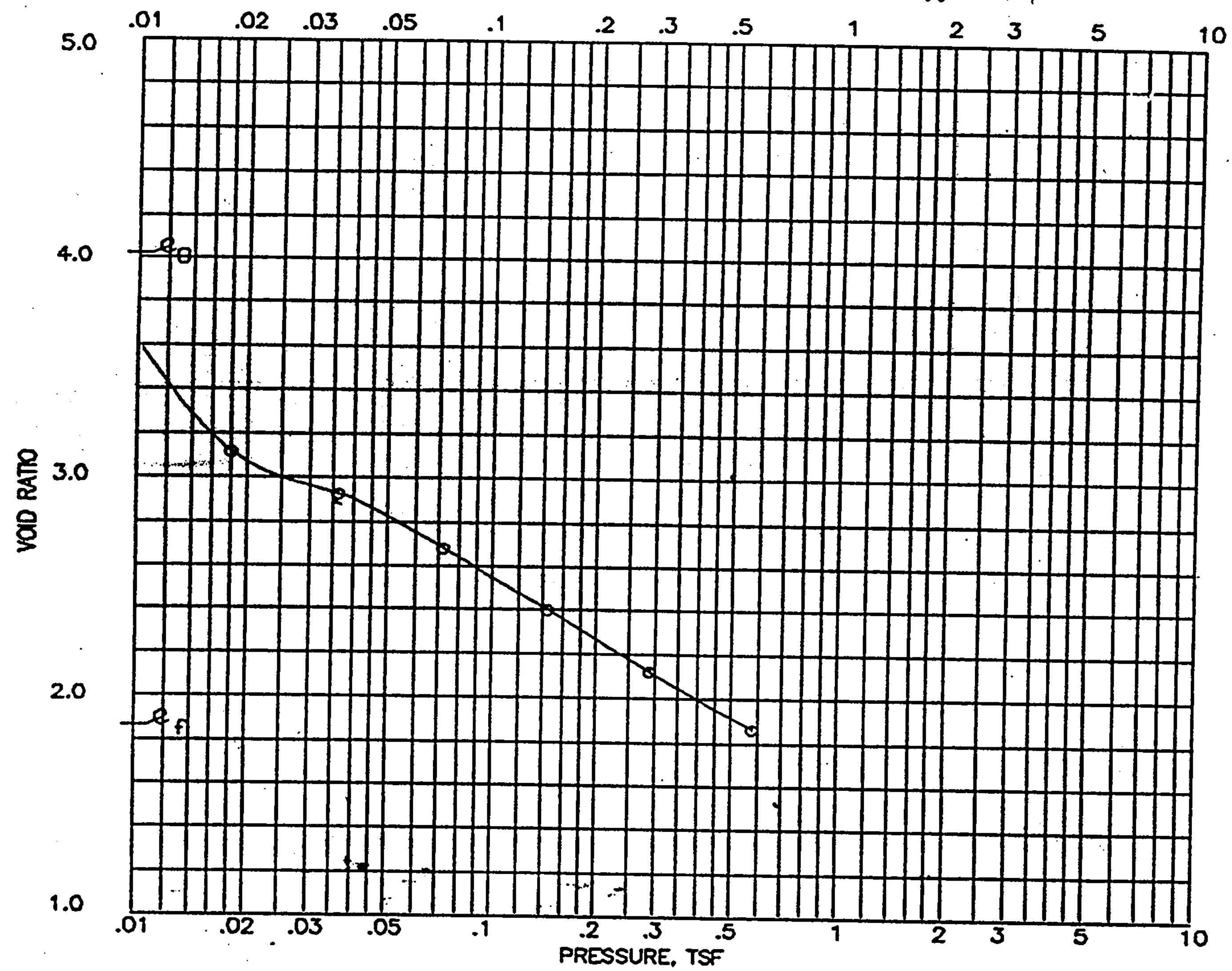

SAMPLE LMØ-1
VOID RATIO
8.00
6.00
4.00
2.00
0.00
0.0001
0.001
0.01
0.1
PRESSURE, TSF

(14)



SELF-WEIGHT CONSOLIDATION

$A = \frac{\pi D^2}{4} = 7.24\ in^2$

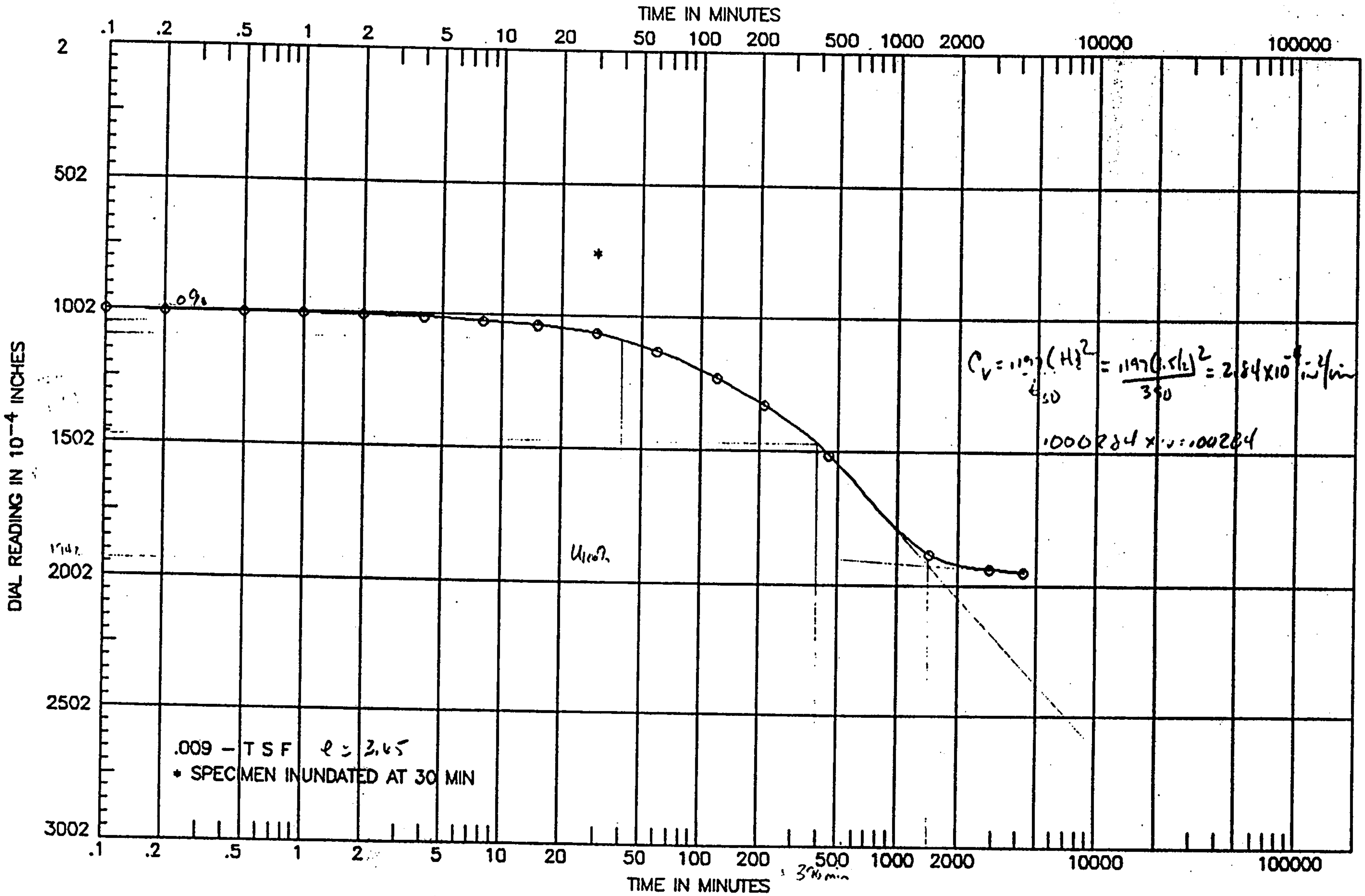


			BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, TSF		WATER CONTENT, %	147.5	67.8
PRECONSOL. PRESSURE, TSF		DRY DENSITY, PCF	33.6	59.0
COMPRESSION INDEX		SATURATION, %	99.2	98.6
TYPE SPECIMEN		VOID RATIO	4.014	1.857
DIA. IN 2.50	HT. IN 1.477	BACK PRESSURE, TSF		

CLASSIFICATION CLAY CH), GRAY		
LL 89	PL 33	PI 56
GS 2.70	D_{10}	

PROJECT TOLEDO HARBOR		
REMARKS:	BORING NO.	SAMPLE NO. LMO-1
	DEPTH/ELEV	TECH. JL
	LABORATORY USAE WES – STF/GL	DATE 06 AUG 93
	CONSOLIDATION TEST REPORT	

SHEET 1 OF 8

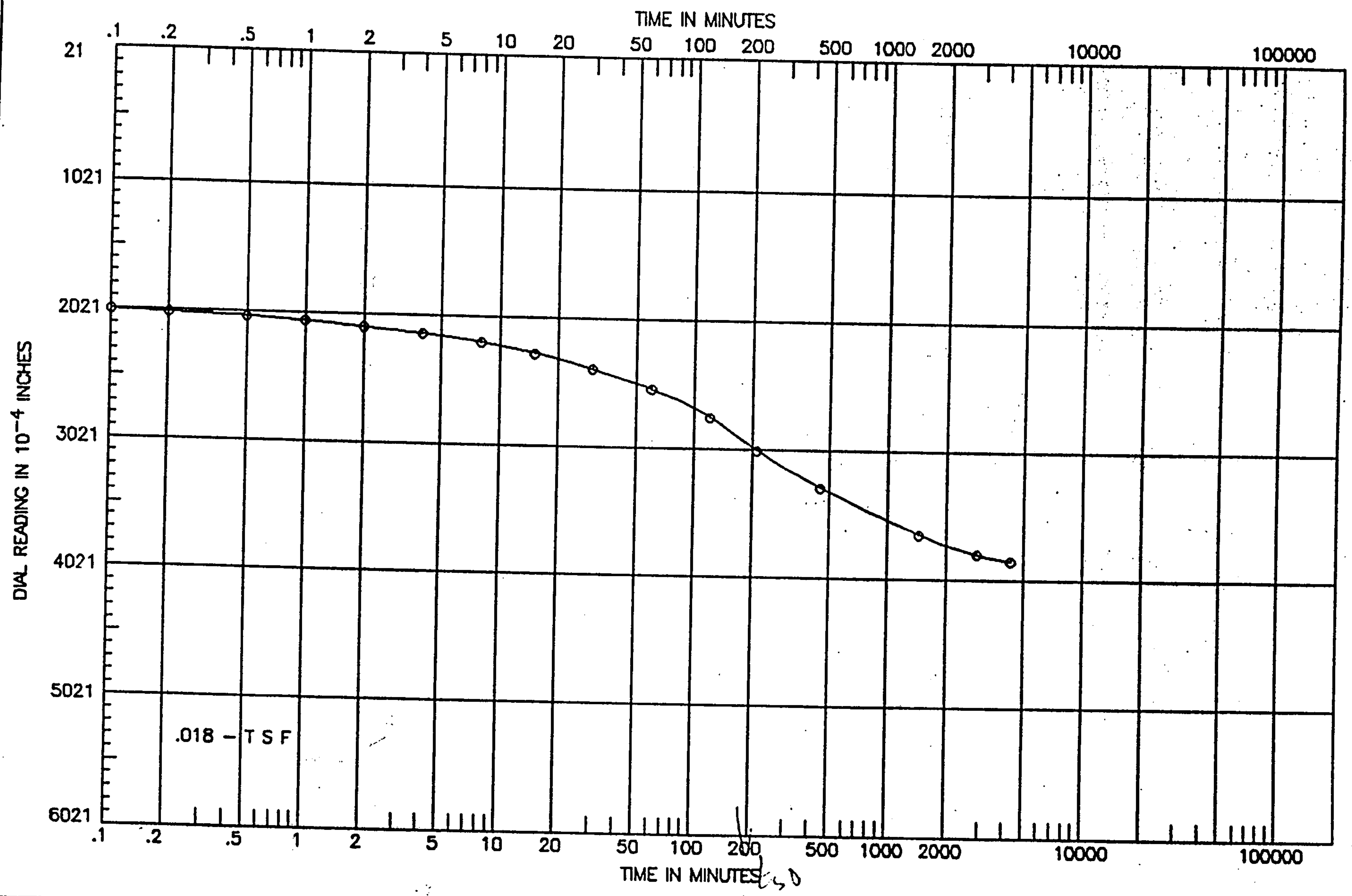


PROJECT	TOLEDO HARBOR		
BORING		SAMPLE NO.	LMO-1
DEPTH/ELEV		DATE	06 AUG 93

CONSOLIDATION TEST TIME CURVES

LABORATORY USAE WES – STF/GL

SHEET 2 OF 8

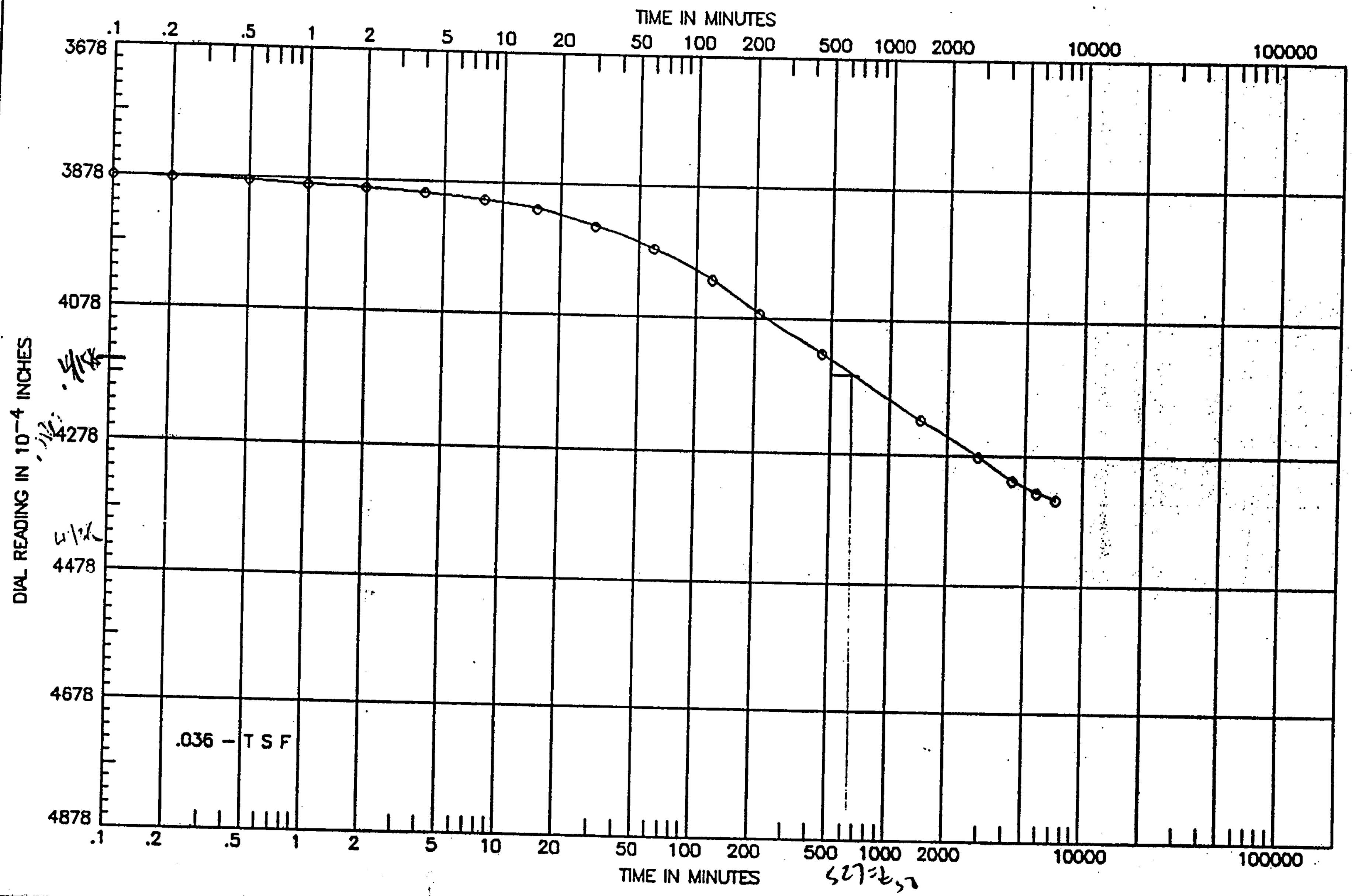


PROJECT TOLEDO HARBOR	
BORING	SAMPLE NO. LMO-1
DEPTH/ELEV	DATE 06 AUG 93

SHEET 3 OF 8

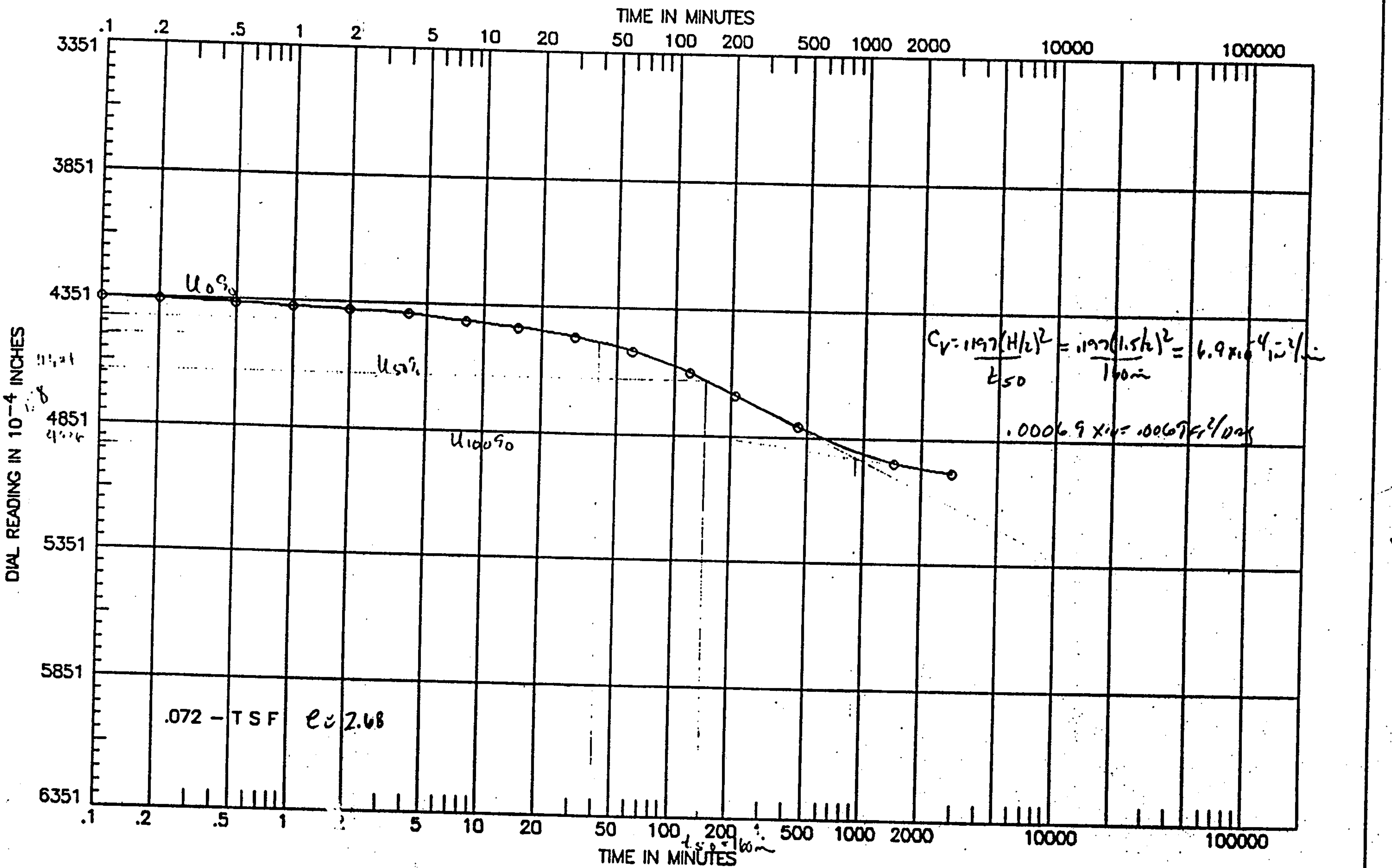
CONSOLIDATION TEST TIME CURVES

LABORATORY USAE WES – STF/GL



PROJECT TOLEDO HARBOR		CONSOLIDATION TEST TIME CURVES
BORING	SAMPLE NO. LMO-1	LABORATORY USAE WES - STF/GL
DEPTH/ELEV	DATE 06 AUG 93	

SHEET 4 OF 8

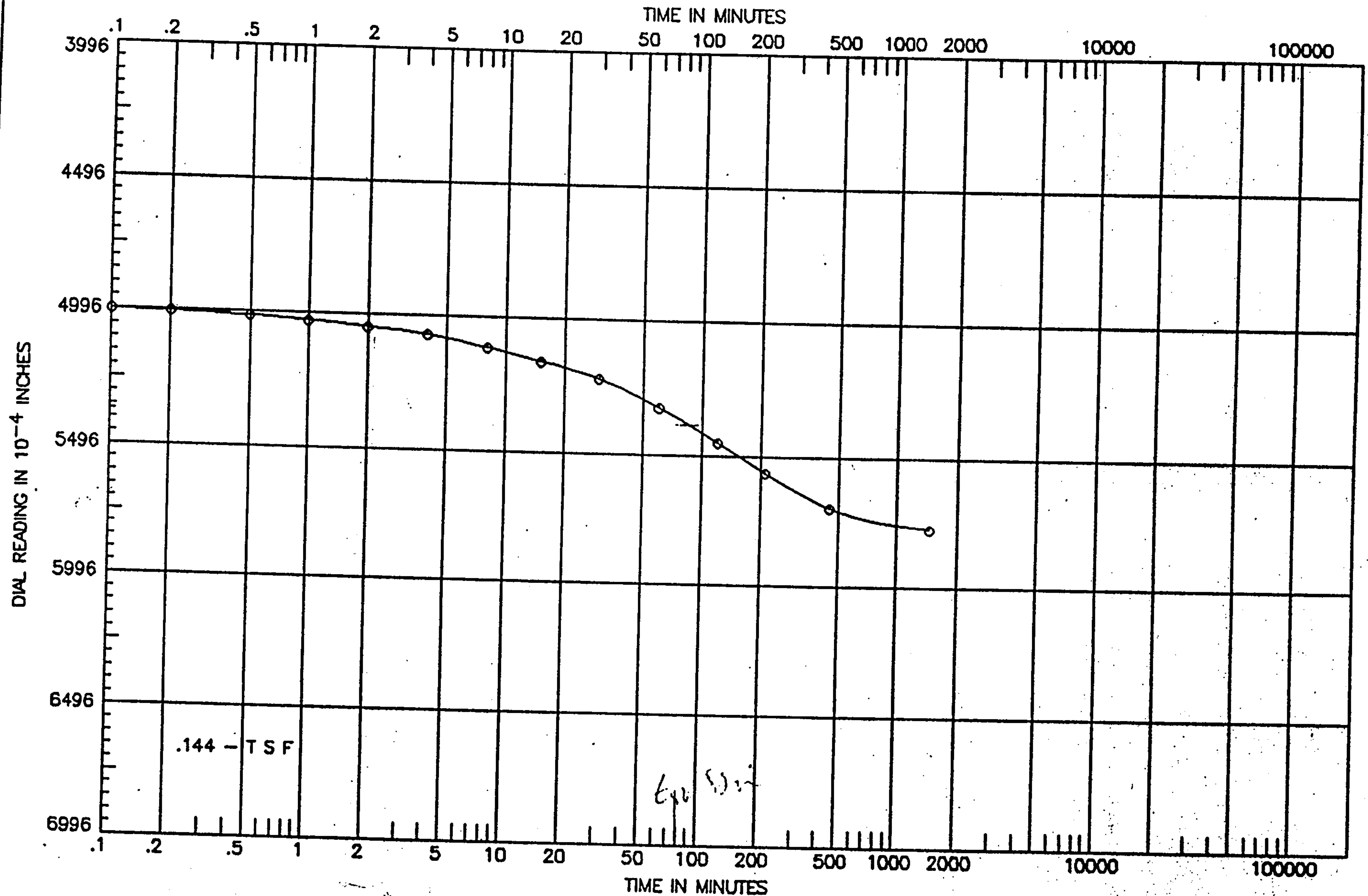


PROJECT TOLEDO HARBOR	
BORING	SAMPLE NO. LMO-1
DEPTH/ELEV	DATE 06 AUG 93

SHEET 5 OF 8

CONSOLIDATION TEST TIME CURVES

LABORATORY USAE WES – STF/GL

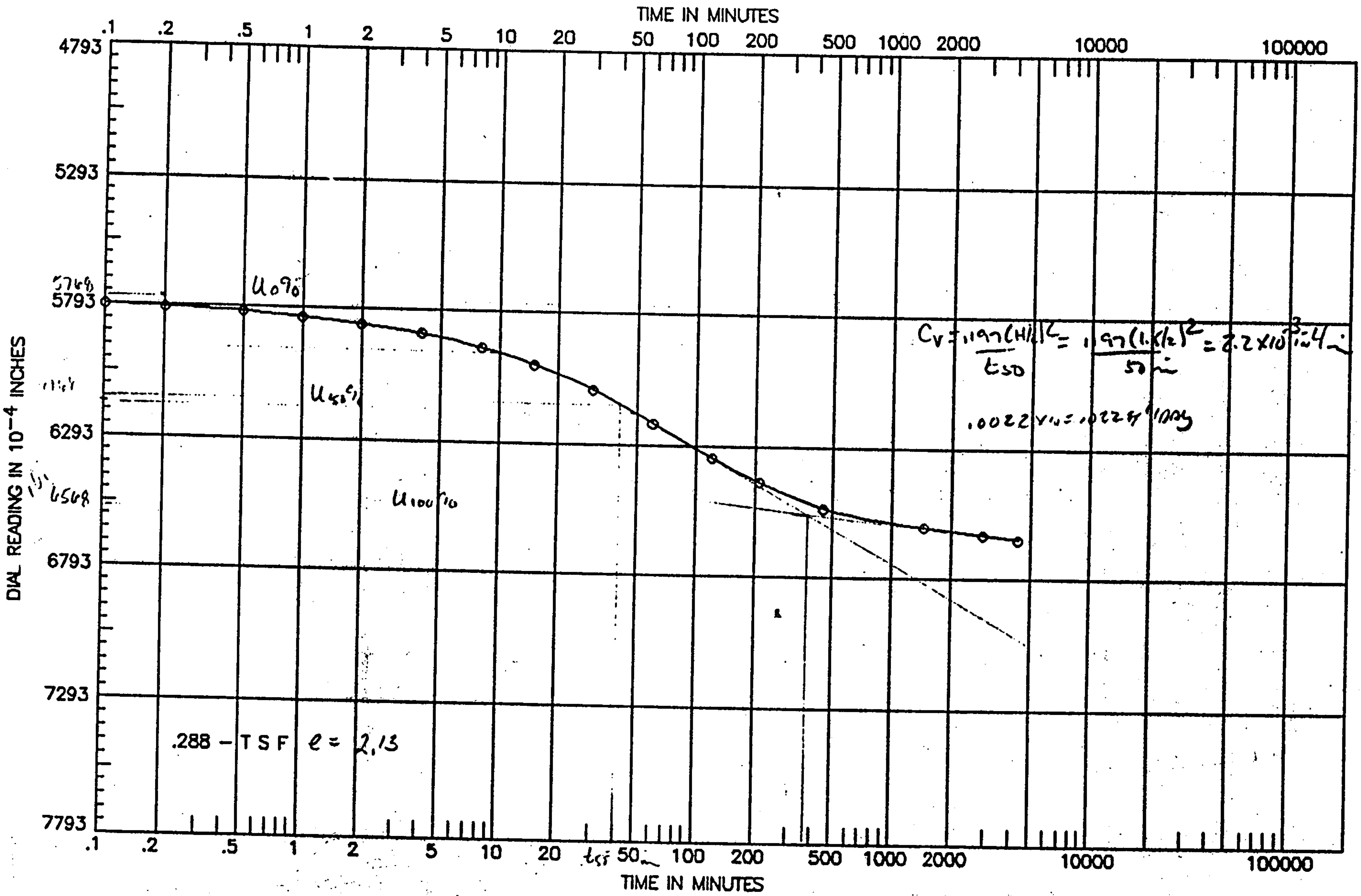


PROJECT TOLEDO HARBOR	
BORING	SAMPLE NO. LMO-1
DEPTH/ELEV	DATE 06 AUG 93

SHEET 6 OF 8

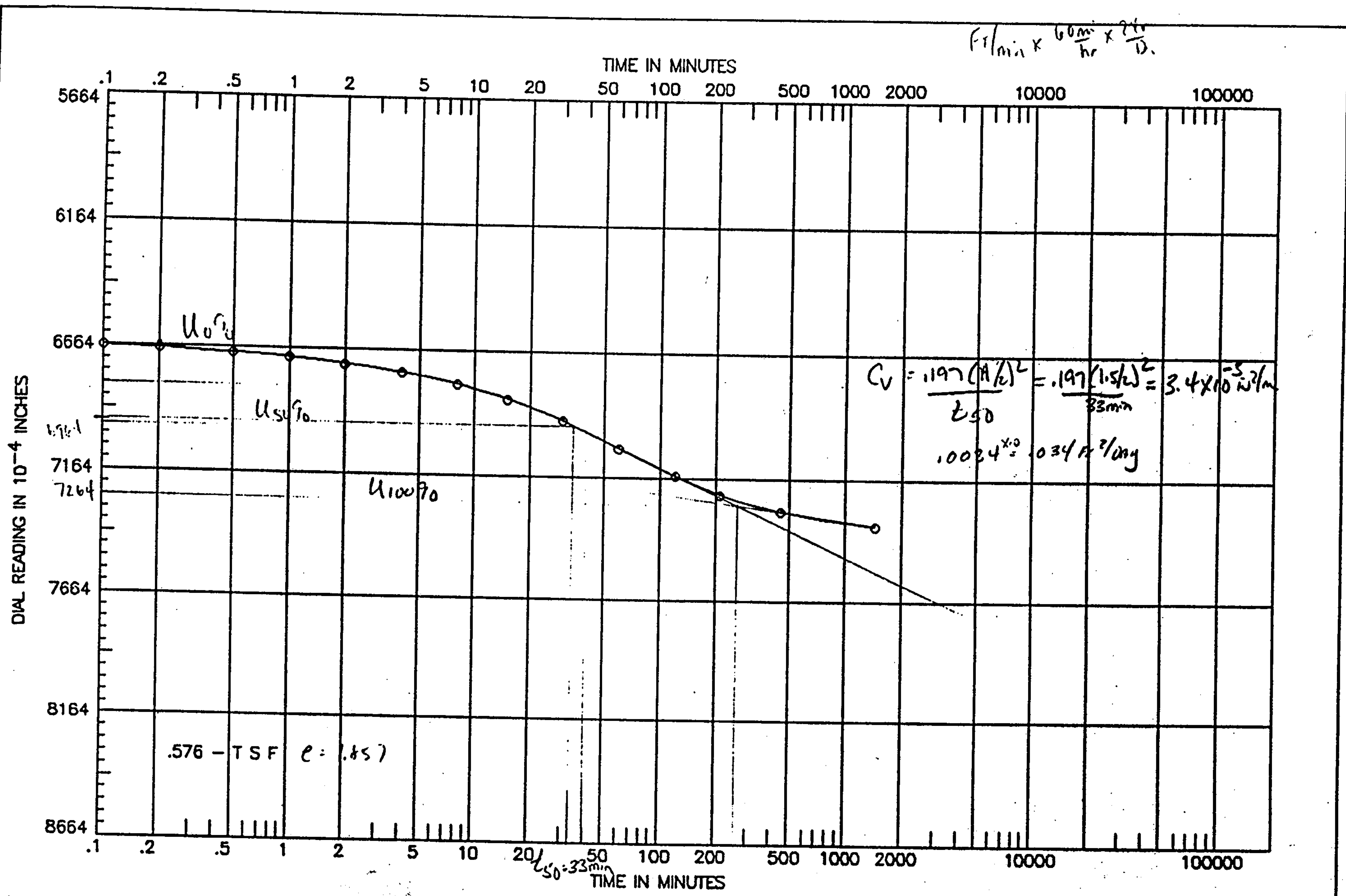
CONSOLIDATION TEST TIME CURVES

LABORATORY USAE WES – STF/GL



PROJECT TOLEDO HARBOR		CONSOLIDATION TEST TIME CURVES
BORING	SAMPLE NO. LMO-1	LABORATORY USAE WES – STF/GL
DEPTH/ELEV	DATE 06 AUG 93	

SHEET 7 OF 8



PROJECT TOLEDO HARBOR		
BORING	SAMPLE NO. LMO-1	
DEPTH/ELEV	DATE 06 AUG 93	

CONSOLIDATION TEST TIME CURVES

LABORATORY USAE WES – STF/GL

SHEET 8 OF 8

SIEVE ANALYSIS

PROJECT: TOLEDO HARBOR
BUFFALO DISTRICT

BORING: SAMPLE: LMO-1 DF: MD5793 .DAT
DEPTH: DATE: 11 AUG 93

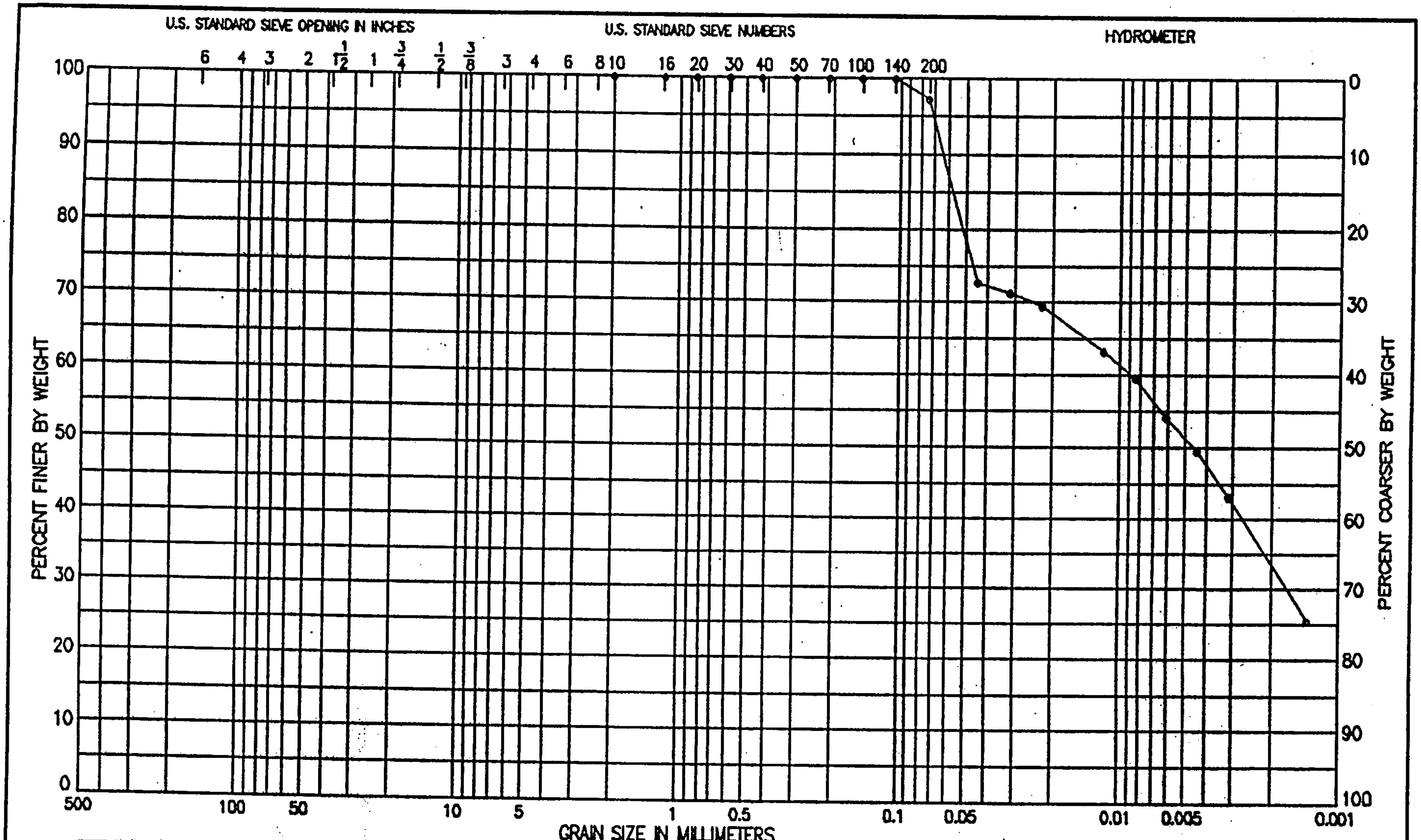
LL: 89 PL: 33 PI: 56 GS: 2.70 WC: .00
CLASSIFICATION: 124
CLAY (CH), GRAY

TOTAL WEIGHT OF SAMPLE: .0 gms.
PARTIAL WEIGHT AFTER SPLIT: 55.5 gms.

WEIGHTS gm.	SIEVE SIZE or NUMBER	OPENING mm	PERCENT FINER	PERCENT COARSER
.0	No 10	2.000	100.0	.0
.0	No 16	1.180	100.0	.0
.0	No 20	.850	100.0	.0
.0	No 30	.600	100.0	.0
.0	No 40	.425	100.0	.0
.0	No 50	.300	100.0	.0
.0	No 70	.212	100.0	.0
.0	No 100	.150	100.0	.0
.0	No 140	.106	100.0	.0
1.5	No 200	.075	97.3	2.7
HYDROMETER:				
RDGS	TEMP			
25.5	22.0	.0444	72.7	27.3
25.0	22.0	.0316	71.3	28.7
24.4	22.0	.0225	69.5	30.5
22.2	22.0	.0119	63.2	36.8
20.9	22.0	.0085	59.5	40.5
19.0	22.0	.0062	54.1	45.9
17.3	22.5	.0044	49.5	50.5
15.0	23.0	.0032	43.2	56.8
9.2	21.0	.0014	25.5	74.5

PERCENT GRAVEL = .0
PERCENT SAND = 2.7
PERCENT FINES = 97.3

EDE



COBBLES	GRAVEL		SAND			SILT or CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

LL 89	PL 33	PI 56	GS 2.70	NAT W,%	ORG,%

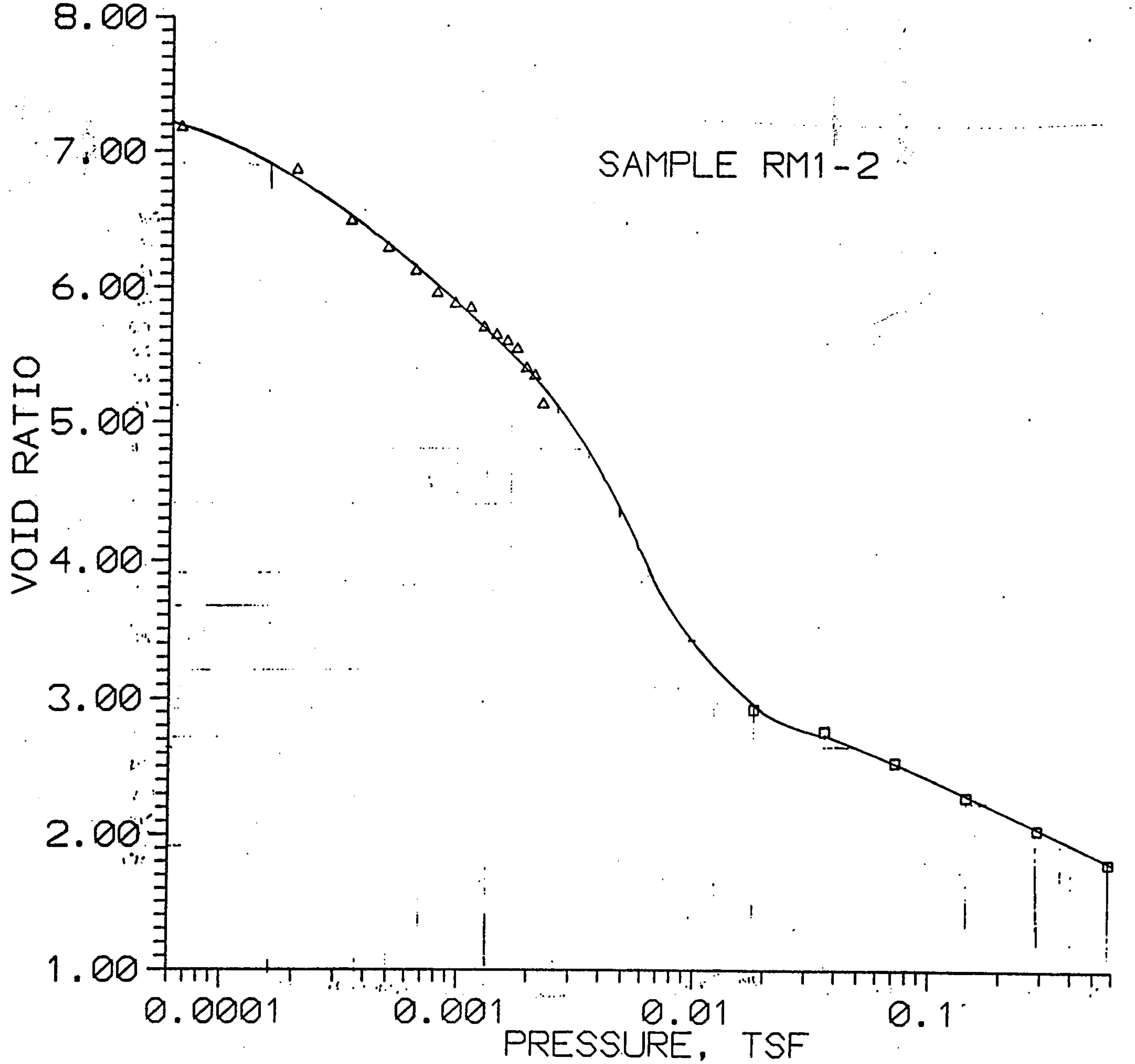
CLASSIFICATION
CLAY (CH), GRAY

PROJECT TOLEDO HARBOR
BUFFALO DISTRICT

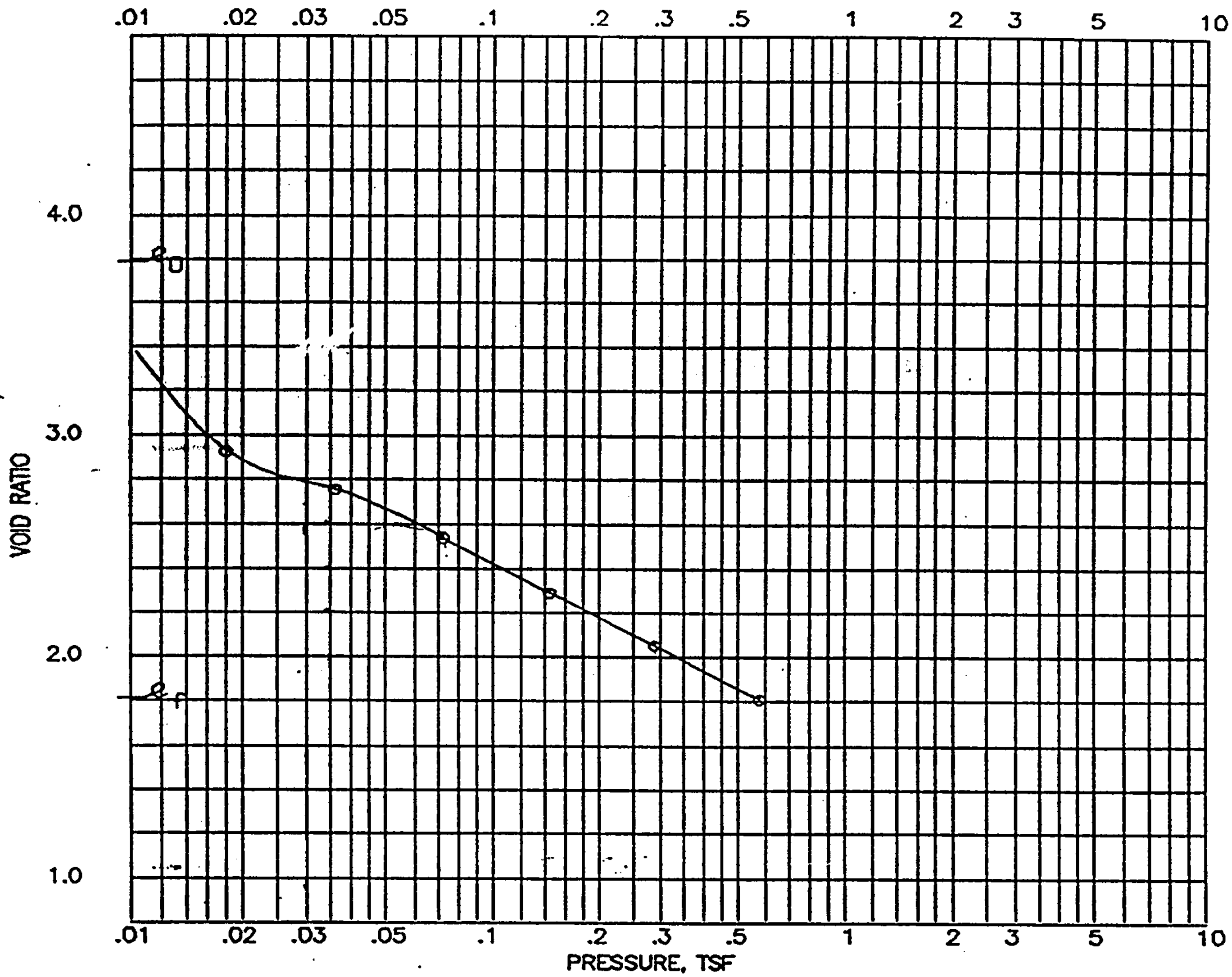
BORING NO. SAMPLE NO. LMO-1

DEPTH/ELEV DATE 11 AUG 93

GRADATION CURVE | LABORATORY USAE WES – STF/GL

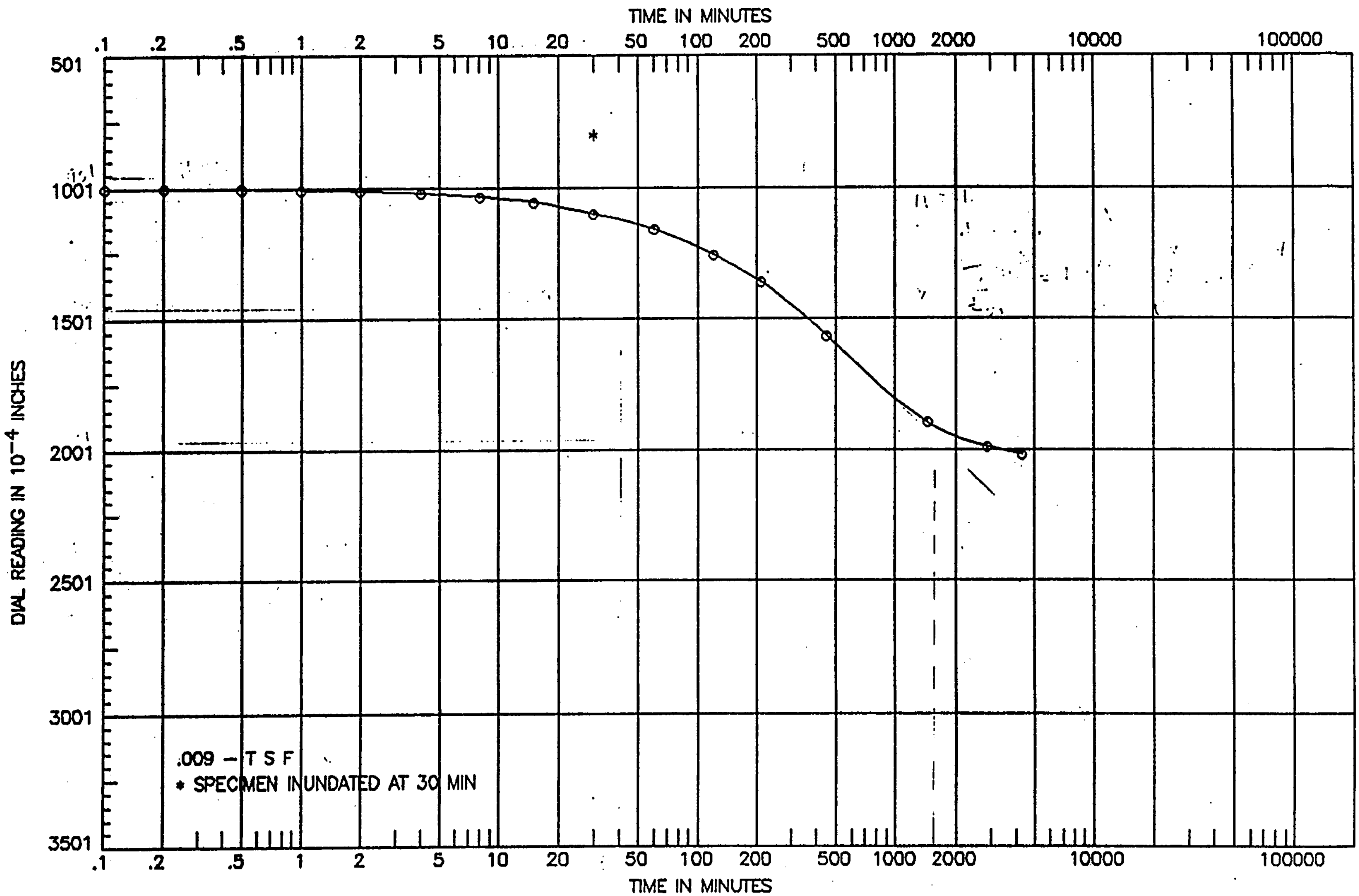


SAMPLE RM1-2
VOID RATIO
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.0001
0.001
0.01
0.1
PRESSURE, TSF



			BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, TSF		WATER CONTENT, %	141.9	68.2
PRECONSOL. PRESSURE, TSF		DRY DENSITY, PCF	34.6	59.0
COMPRESSION INDEX		SATURATION, %	99.4	100 +
TYPE SPECIMEN		VOID RATIO	3.783	1.803
DIA. IN 2.50	HT. IN 1.510	BACK PRESSURE, TSF		
CLASSIFICATION CLAY (CH), GRAY				
LL 88 / PL 31 / PI 57		PROJECT TOLEDO HARBOR		
GS 2.65	D_{10}			
REMARKS:		BORING NO.	SAMPLE NO. RM1-2	
		DEPTH/ELEV	TECH. JL	
		LABORATORY USAE WES - STF/GL	DATE 06 AUG 93	
		CONSOLIDATION TEST REPORT		

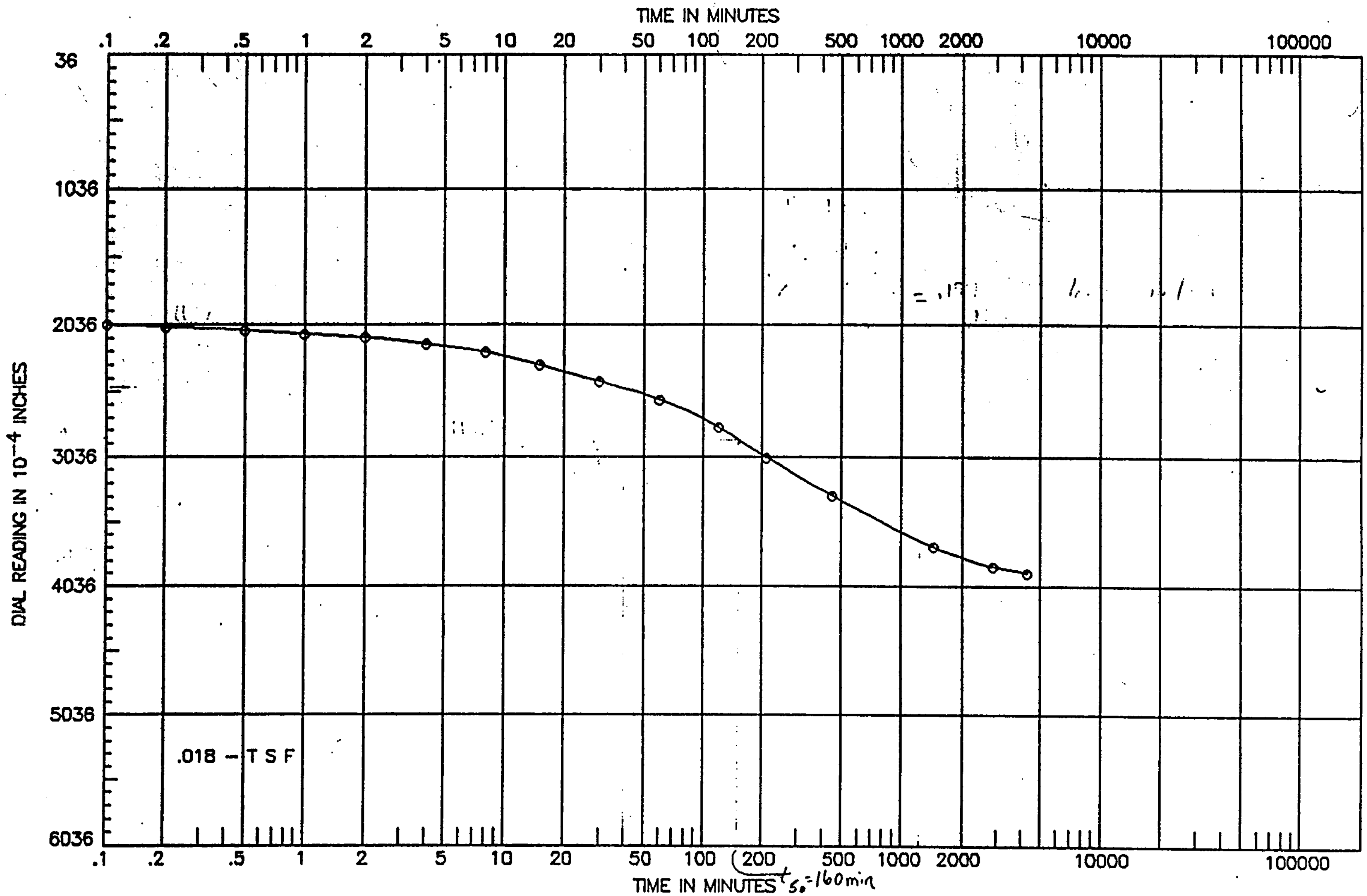
SHEET 1 OF 8



PROJECT TOLEDO HARBOR		CONSOLIDATION TEST TIME CURVES
BORING	SAMPLE NO. RM1-2	LABORATORY USAE WES — STF/GL
DEPTH/ELEV	DATE 06 AUG 93	

SHEET 2 OF 8

(82)

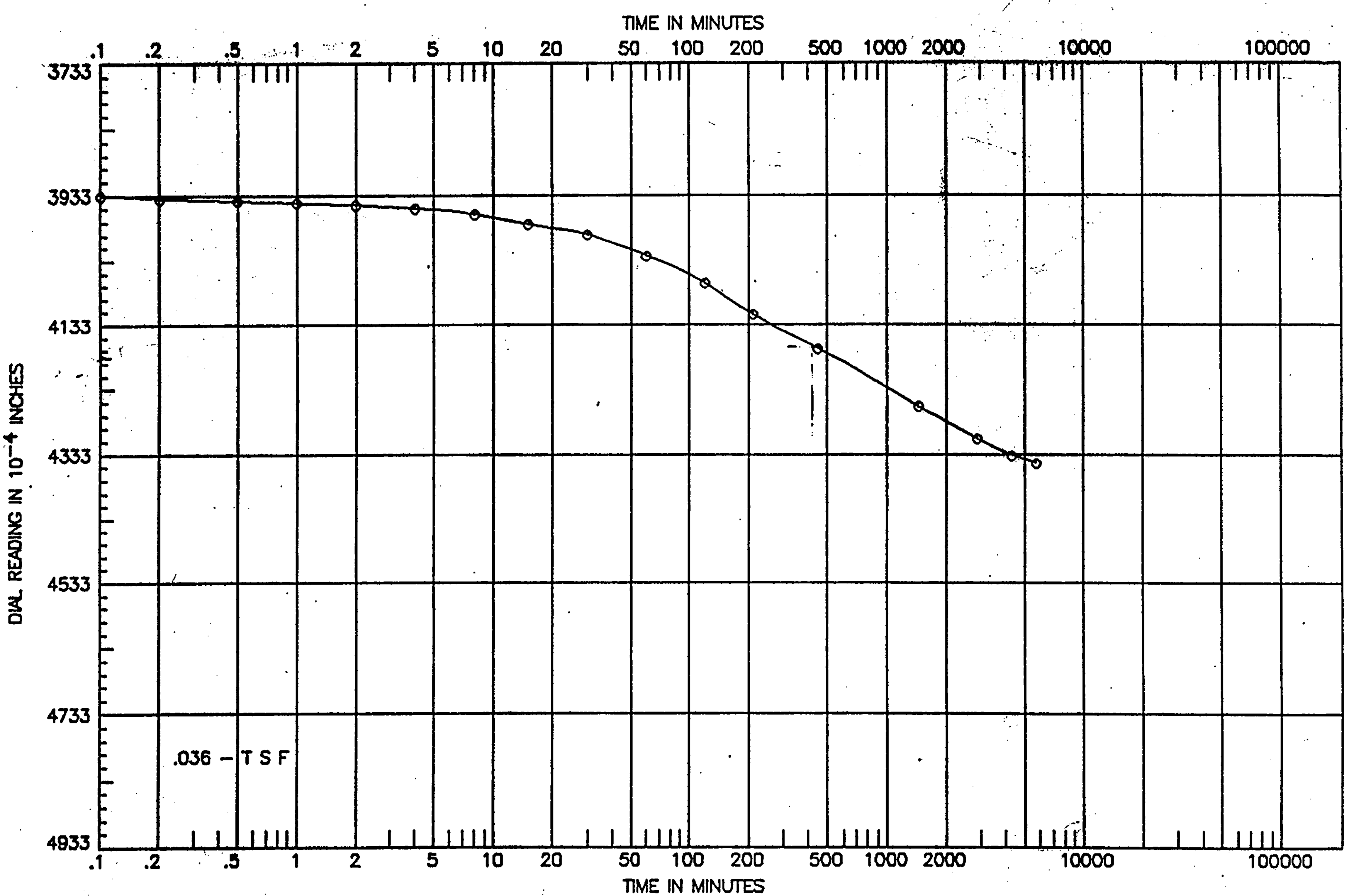


PROJECT TOLEDO HARBOR	
BORING	SAMPLE NO. RM1-2
DEPTH/ELEV	DATE 06 AUG 93

CONSOLIDATION TEST TIME CURVES

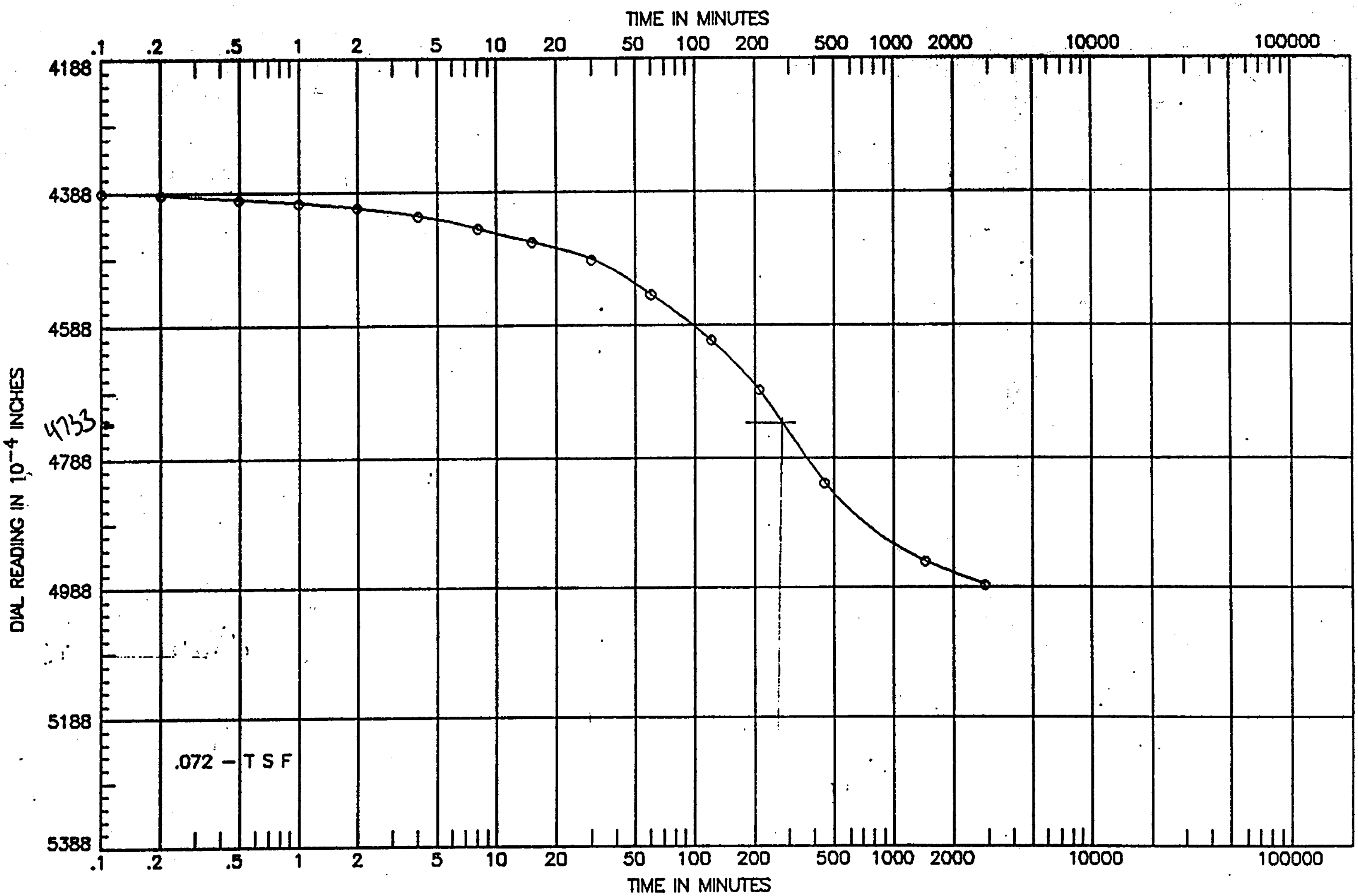
LABORATORY USAE WES — STF/GL

SHEET 3 OF 8



PROJECT TOLEDO HARBOR		CONSOLIDATION TEST TIME CURVES
		LABORATORY USAE WES – STF/GL
BORING	SAMPLE NO. RM1–2	
DEPTH/ELEV	DATE 06 AUG 93	

SHEET 4 OF 8

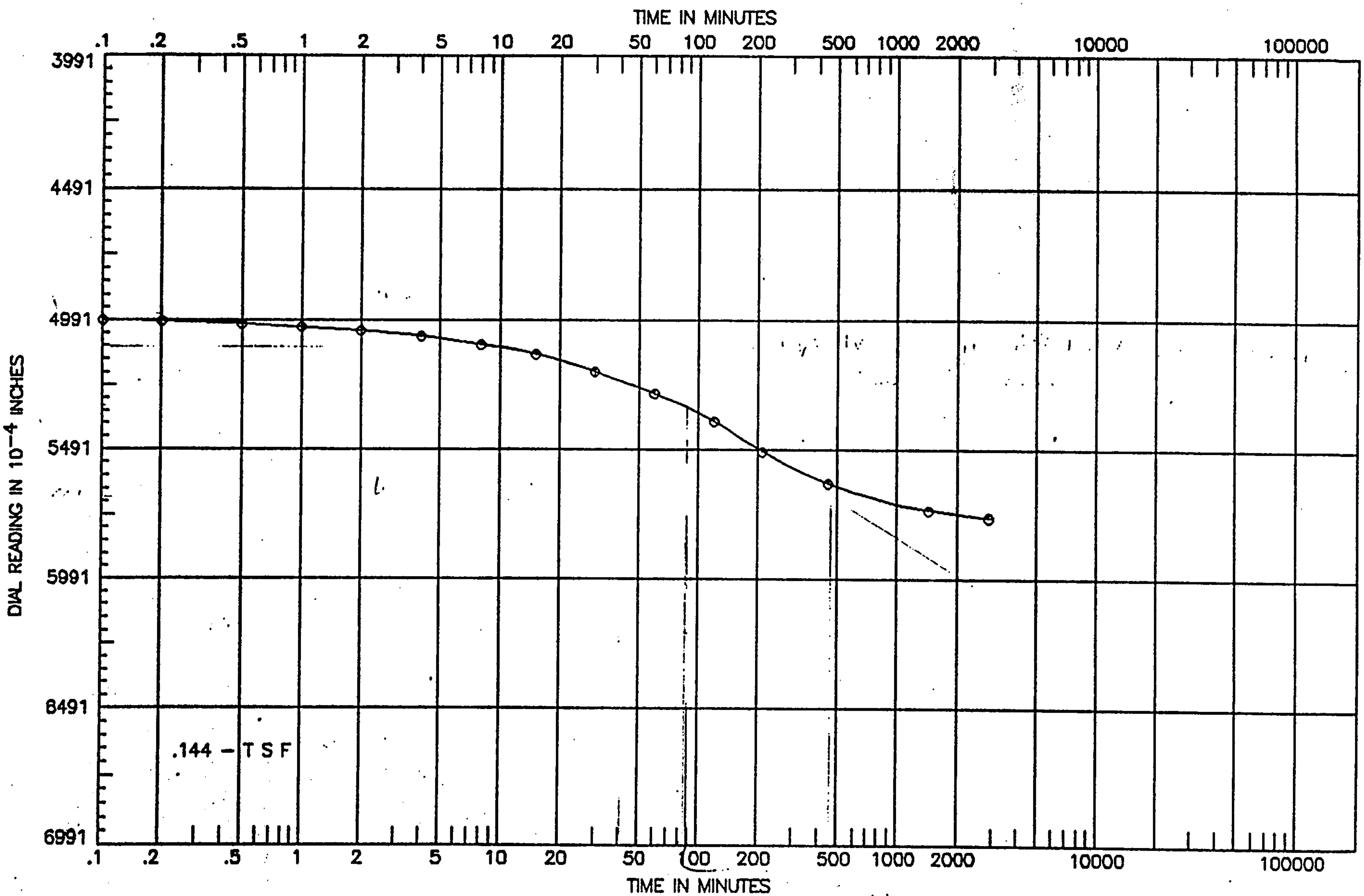


PROJECT	TOLEDO HARBOR		
BORING		SAMPLE NO.	RM1–2
DEPTH/ELEV		DATE	06 AUG 93

CONSOLIDATION TEST TIME CURVES

LABORATORY USAE WES – STF/GL

SHEET 5 OF 8

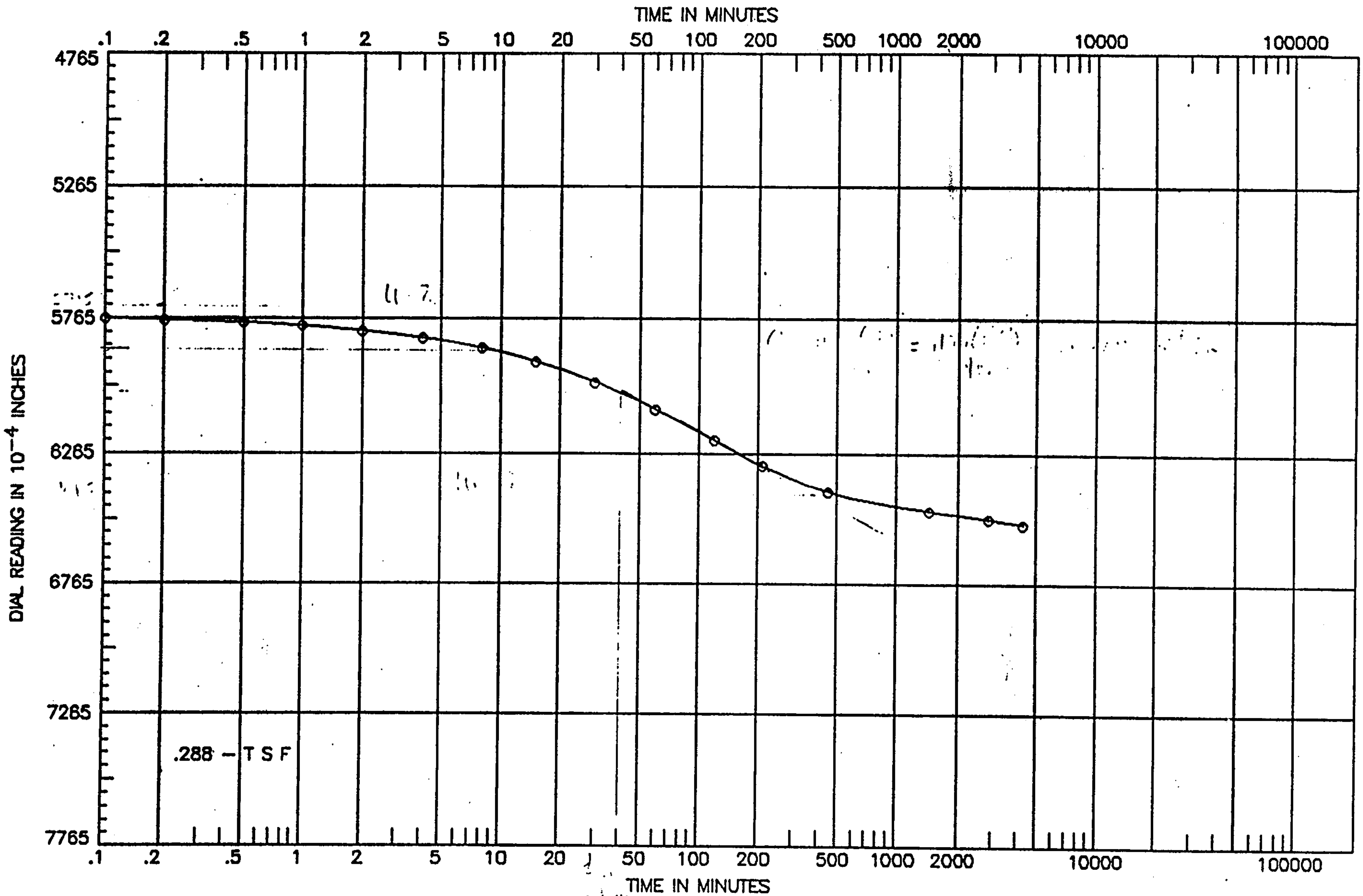


PROJECT TOLEDO HARBOR	
BORING	SAMPLE NO. RM1-2
DEPTH/ELEV	DATE 06 AUG 93

CONSOLIDATION TEST TIME CURVES

LABORATORY USAE WES — STF/GL

SHEET 6 OF 8

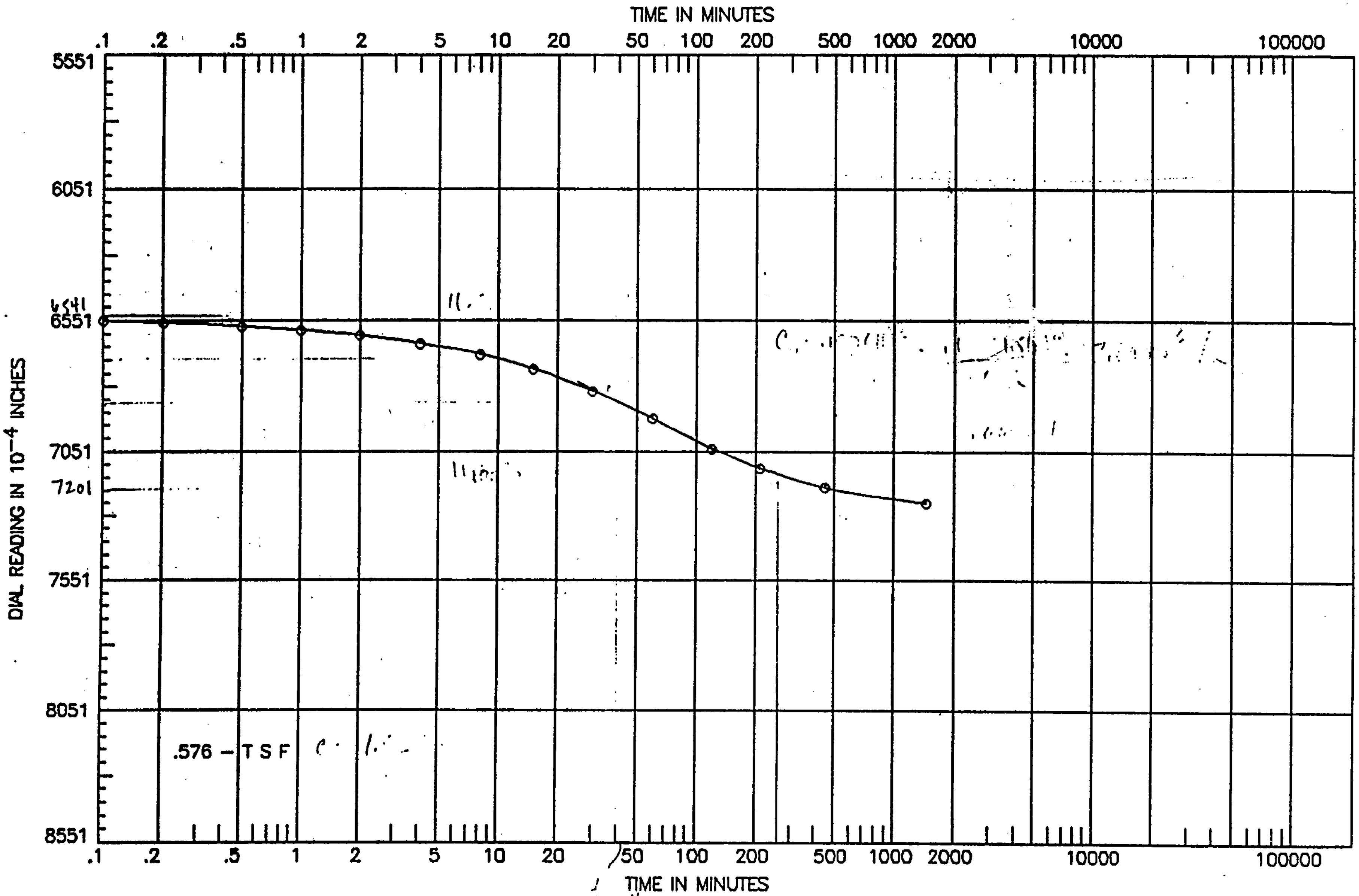


PROJECT TOLEDO HARBOR	
BORING	SAMPLE NO. RM1-2
DEPTH/ELEV	DATE 06 AUG 93

CONSOLIDATION TEST TIME CURVES

LABORATORY USAE WES — STF/GL

SHEET 7 OF 8



PROJECT TOLEDO HARBOR	
BORING	SAMPLE NO. RM1-2
DEPTH/ELEV	DATE 06 AUG 93

SHEET 8 OF 8

CONSOLIDATION TEST TIME CURVES

LABORATORY USAE WES – STF/GL

SIEVE ANALYSIS

PROJECT: TOLEDO HARBOR
BUFFALO DISTRICT

BORING: SAMPLE: RM1-2 DF: MD5793 .DAT
DEPTH: DATE: 11 AUG 93

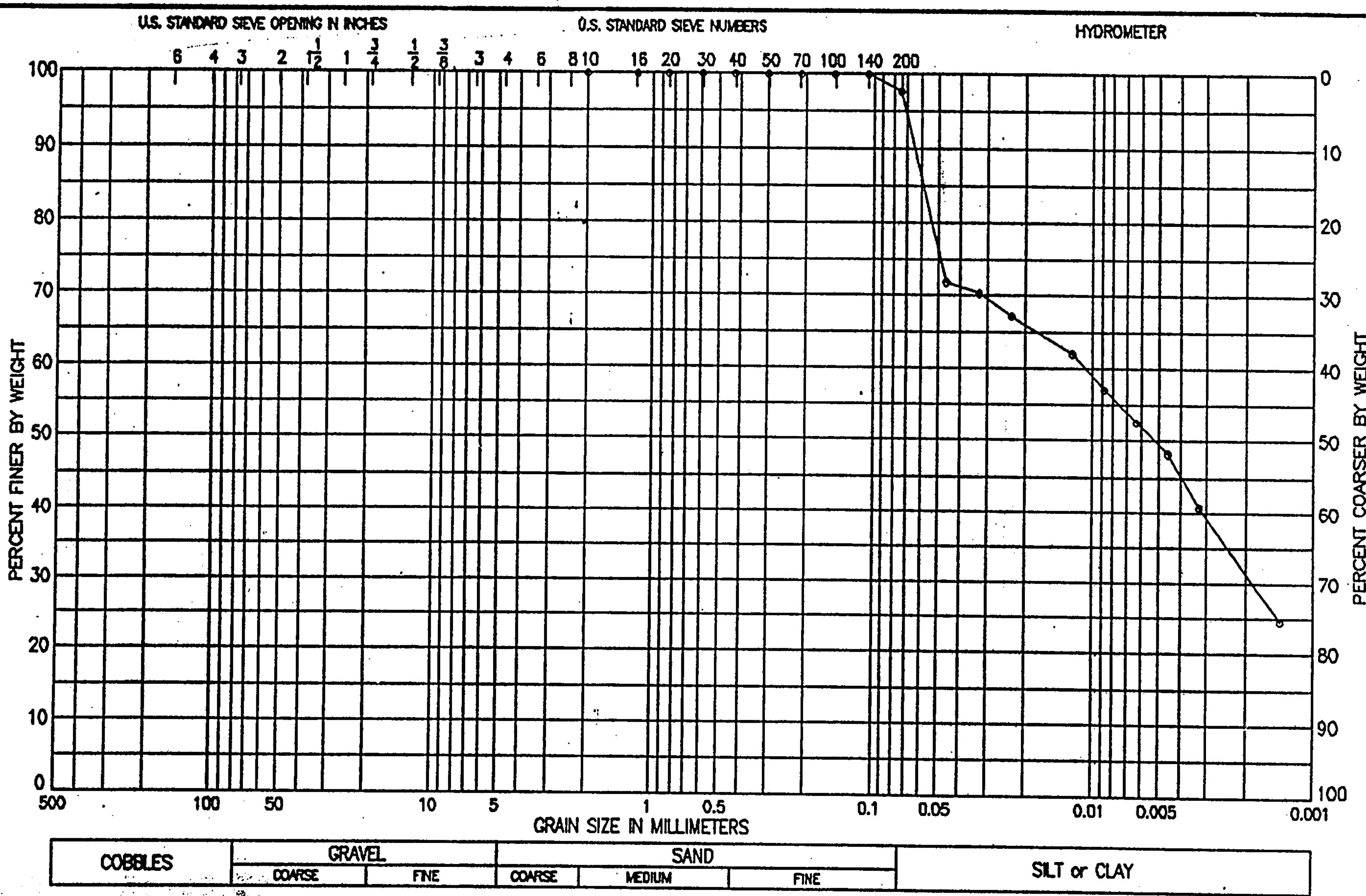
LL: 88 PL: 31 PI: 57 GS: 2.65 WC: .00
CLASSIFICATION: 108
CLAY (CH), GRAY

TOTAL WEIGHT OF SAMPLE: .0 gms.
PARTIAL WEIGHT AFTER SPLIT: 52.3 gms.

WEIGHTS gm.	SIEVE SIZE or NUMBER	OPENING mm	PERCENT FINER	PERCENT COARSER
.0	No 10	2.000	100.0	.0
.0	No 16	1.180	100.0	.0
.0	No 20	.850	100.0	.0
.0	No 30	.600	100.0	.0
.0	No 40	.425	100.0	.0
.0	No 50	.300	100.0	.0
.0	No 70	.212	100.0	.0
.0	No 100	.150	100.0	.0
.0	No 140	.106	100.0	.0
1.2	No 200	.075	97.7	2.3
HYDROMETER:				
RDGS	TEMP			
23.5	22.0	.0461	71.9	28.1
23.0	22.0	.0328	70.3	29.7
22.0	22.0	.0234	67.3	32.7
20.3	22.0	.0123	62.0	38.0
18.7	22.0	.0089	57.1	42.9
17.2	22.0	.0064	52.5	47.5
15.7	22.5	.0046	48.2	51.8
13.3	22.5	.0033	40.8	59.2
8.3	21.0	.0014	24.6	75.4

PERCENT GRAVEL = .0
PERCENT SAND = 2.3
PERCENT FINES = 97.7

EDE



LL 88	PL 31	PI 57	GS 2.65	NAT W,%	ORG,%

CLASSIFICATION
CLAY (CH), GRAY

PROJECT TOLEDO HARBOR
BUFFALO DISTRICT

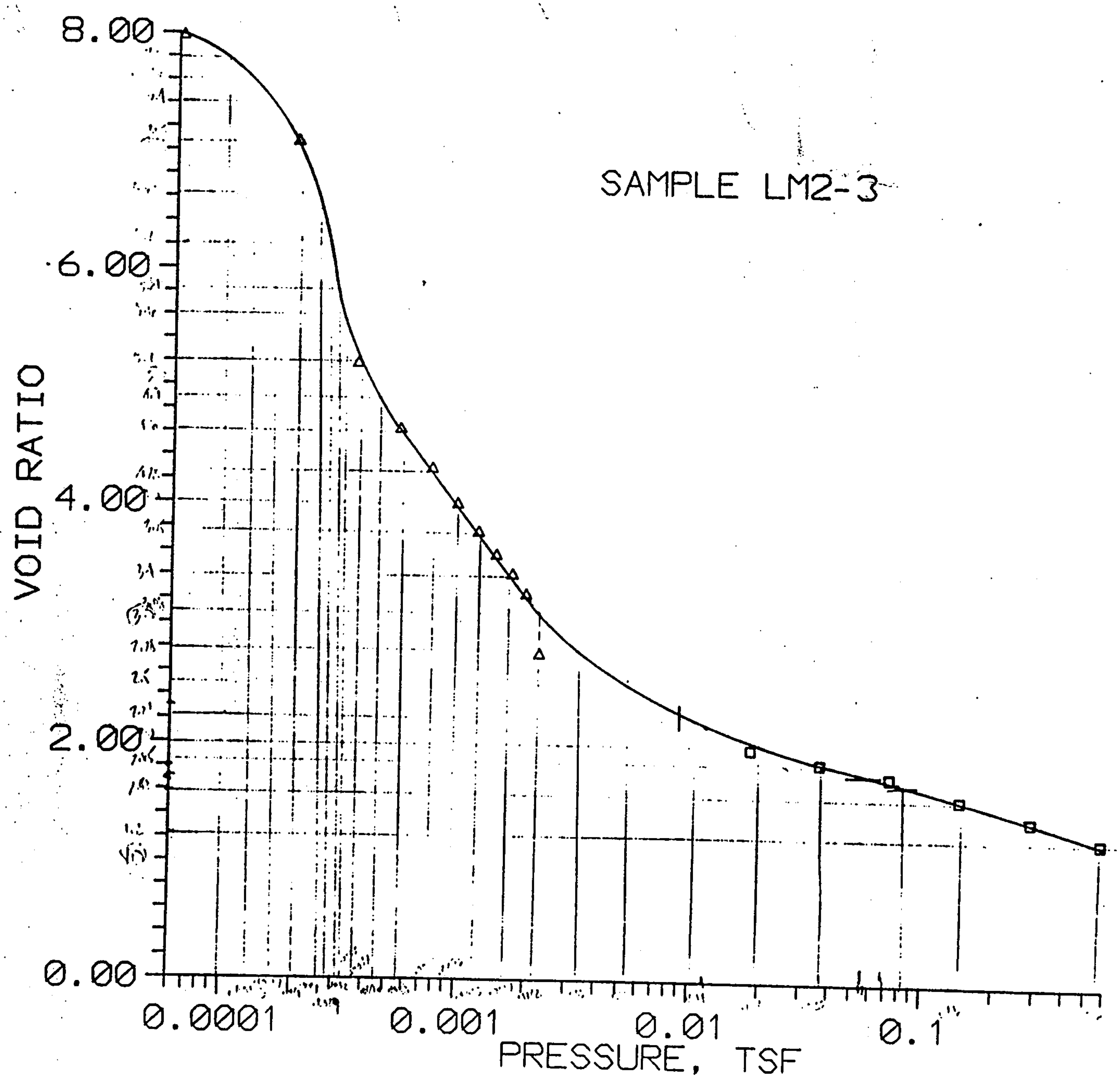
BORING NO. SAMPLE NO. RM1-2

DEPTH/ELEV DATE 11 AUG 93

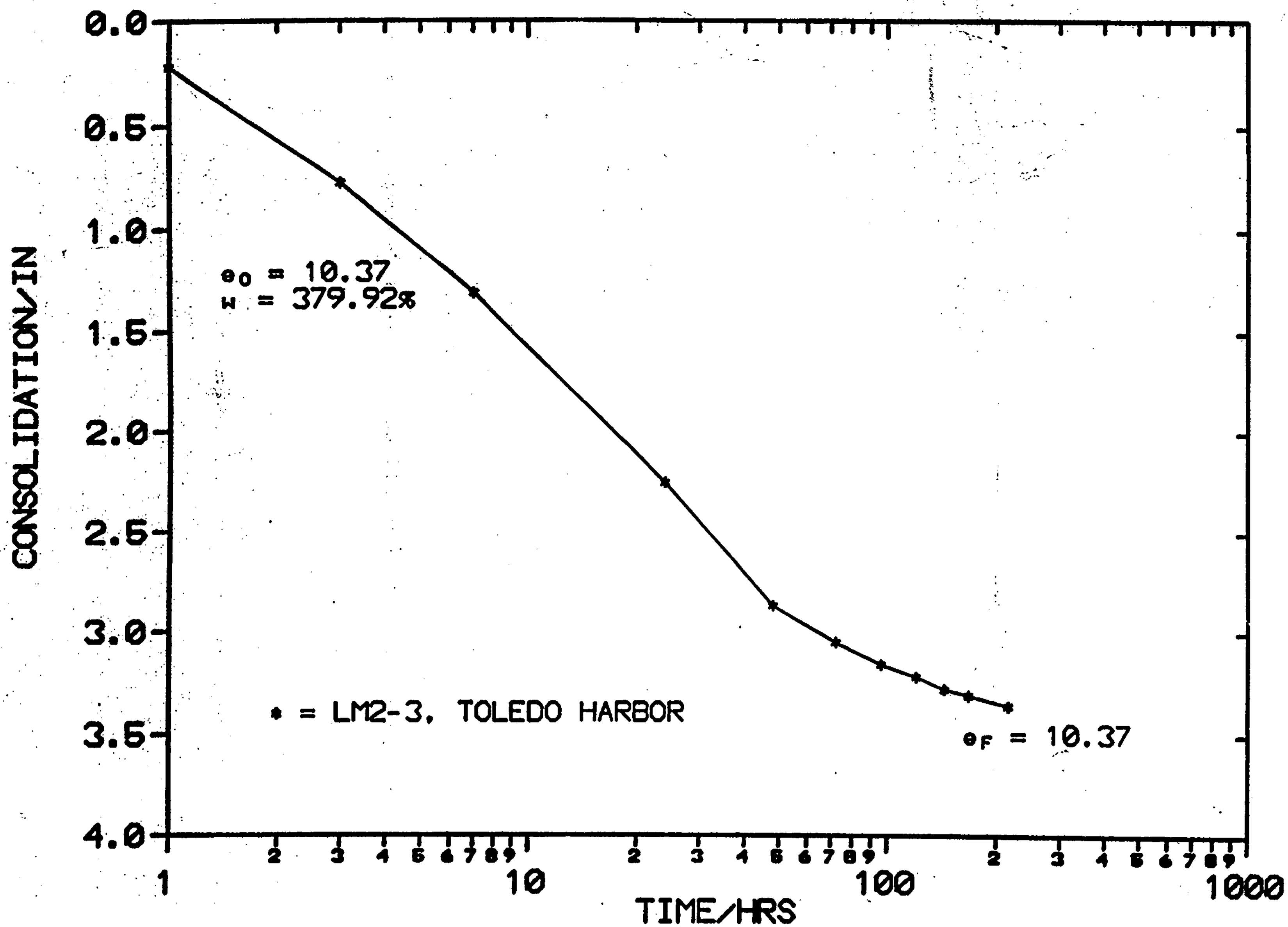
GRADATION CURVE

LABORATORY USAE WES - STF/GL

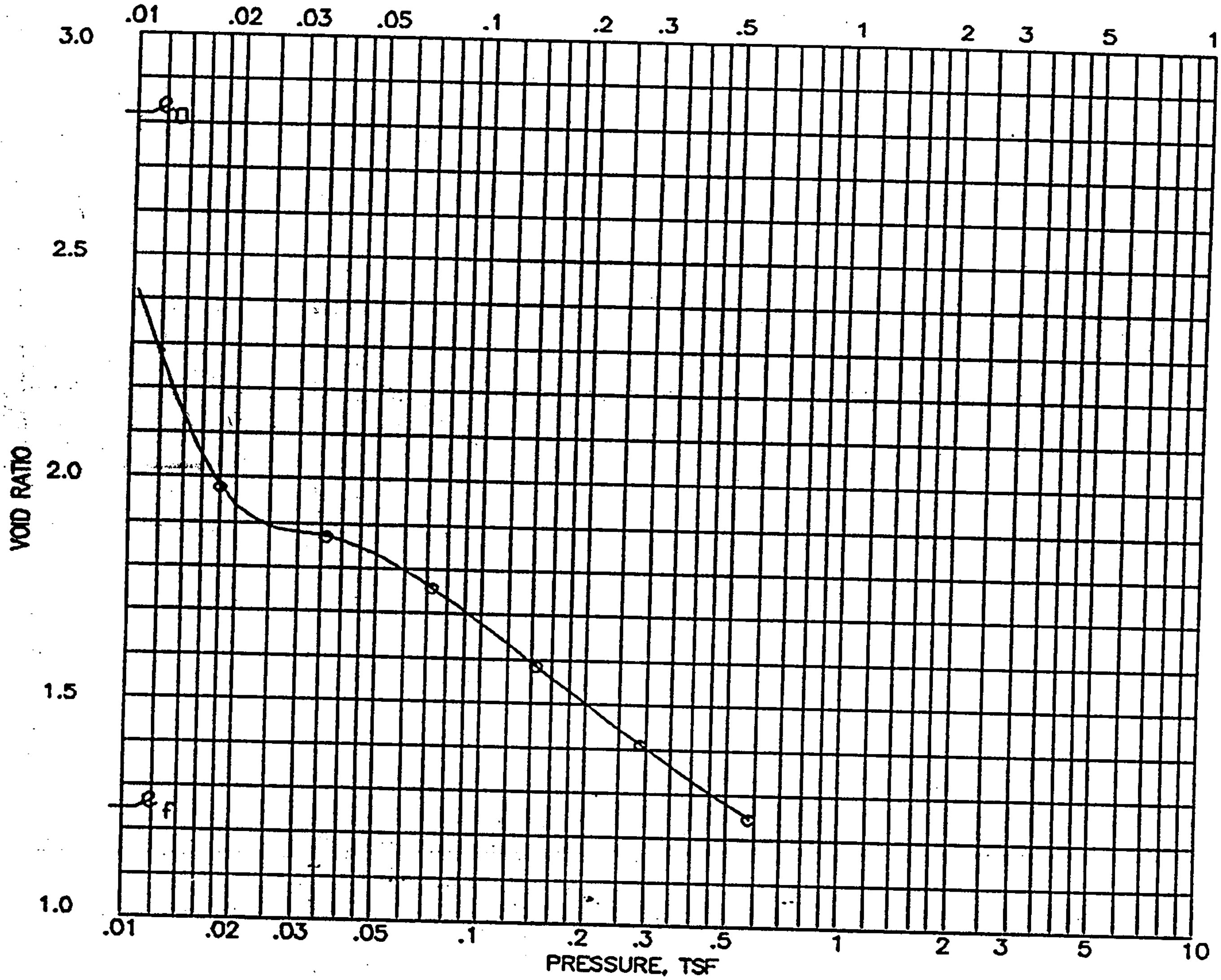
(36)


SAMPLE LM2-3
VOID RATIO
8.00
6.00
4.00
2.00
0.00
0.0001
0.001
0.01
0.1
PRESSURE, TSF

(37)



SELF-WEIGHT CONSOLIDATION

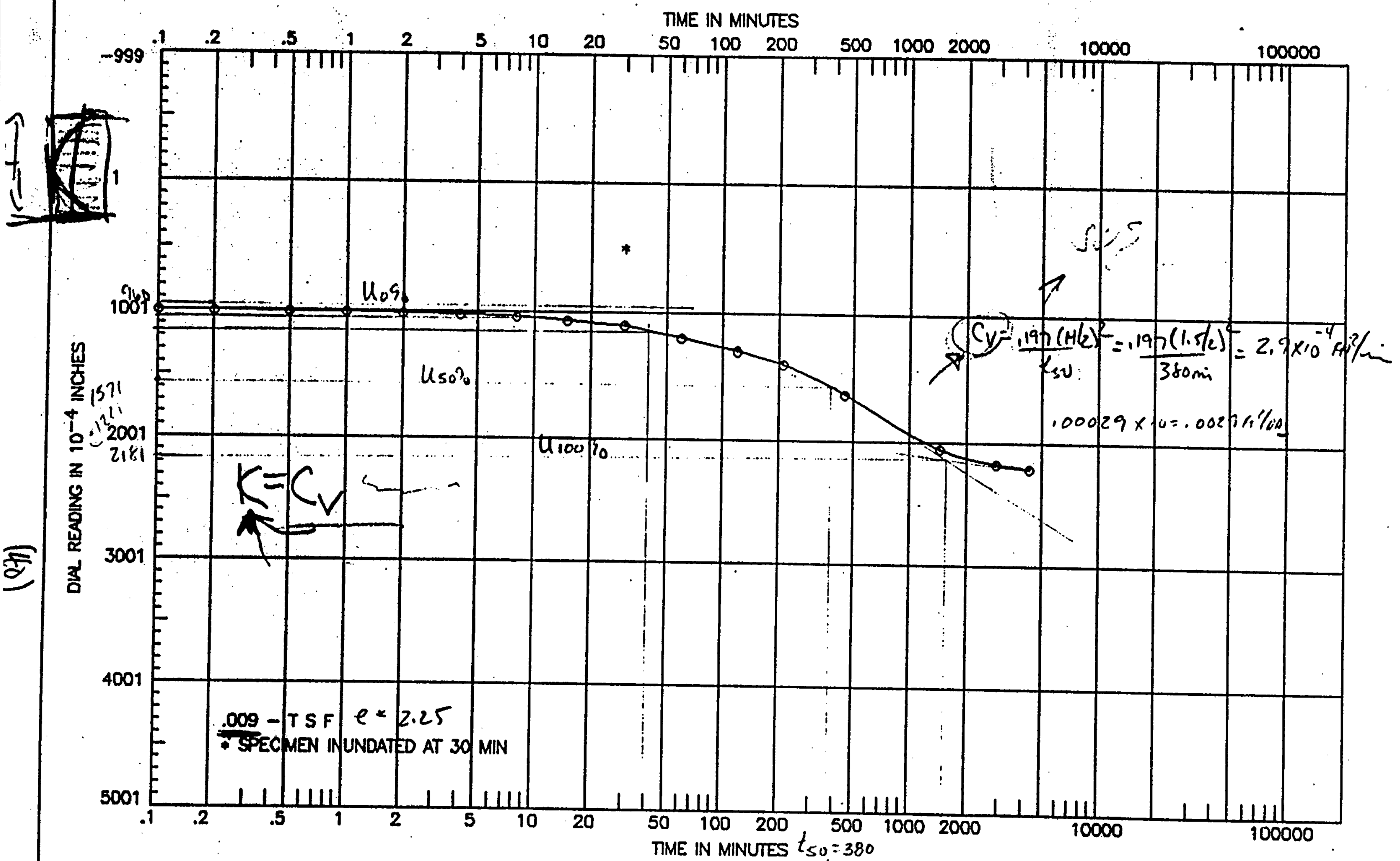


			BEFORE TEST	AFTER TEST
OVERBURDEN PRESSURE, TSF		WATER CONTENT, %	103.5	45.9
PRECONSOL. PRESSURE, TSF		DRY DENSITY, PCF	44.7	76.0
COMPRESSION INDEX		SATURATION, %	100 +	100 +
TYPE SPECIMEN		VOID RATIO	2.817	1.244
DIA. IN 2.50	HT. IN 1.500	BACK PRESSURE, TSF		

CLASSIFICATION	SANDY CLAY (CH), GRAY
LL 60 PL 23 PI 37	PROJECT TOLEDO HARBOR
GS 2.73 D_{10}	
REMARKS:	BORING NO. — SAMPLE NO. LM2-3
	DEPTH/ELEV — TECH. JL
	LABORATORY USAE WES – STF/GL — DATE 06 AUG 93

CONSOLIDATION TEST REPORT

SHEET 1 OF 8

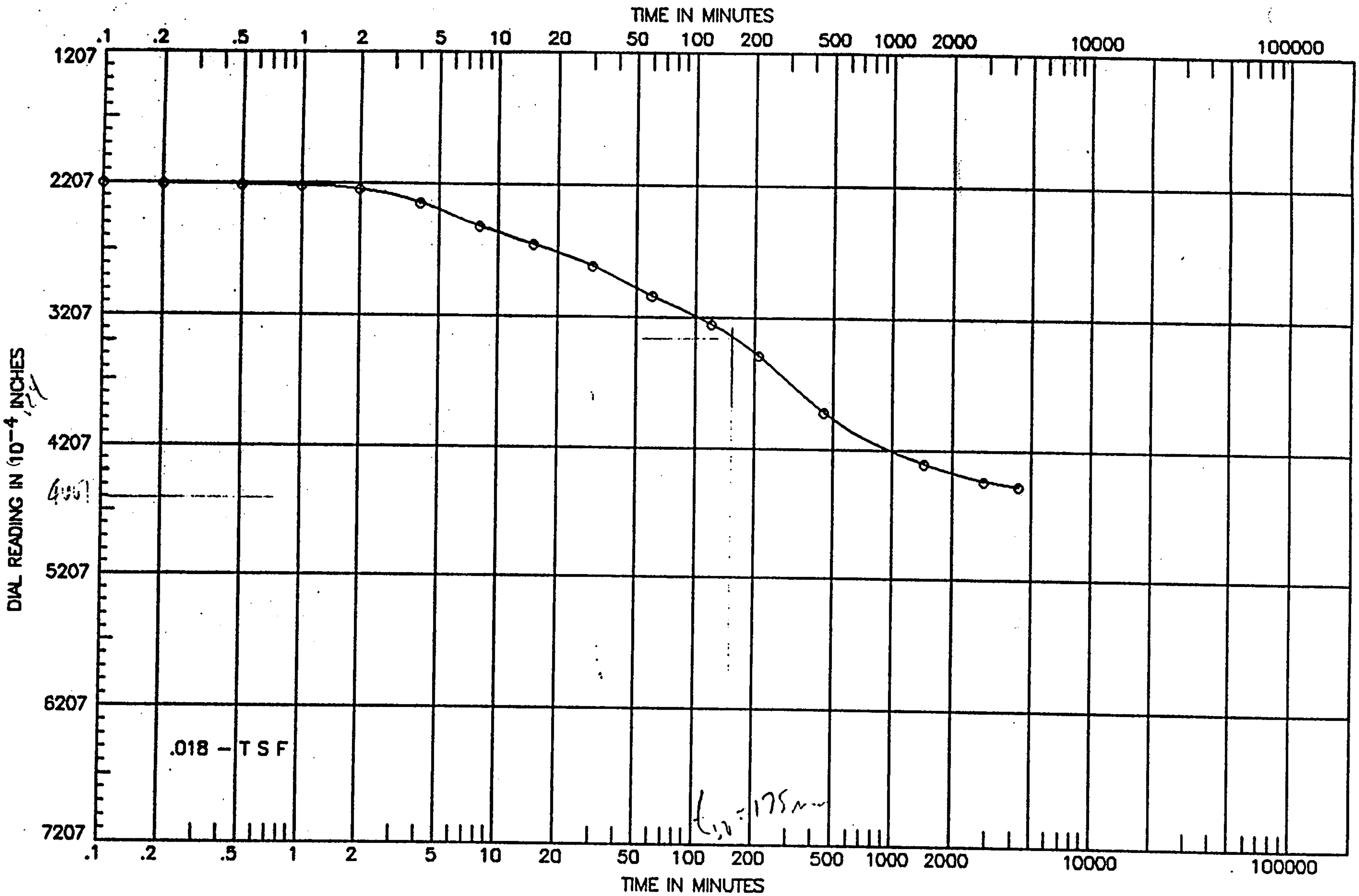


PROJECT	TOLEDO HARBOR
BORING	SAMPLE NO. LM2-3
DEPTH/ELEV	DATE 06 AUG 93

CONSOLIDATION TEST TIME CURVES

LABORATORY USAE WES – STF/GL

SHEET 2 OF 8

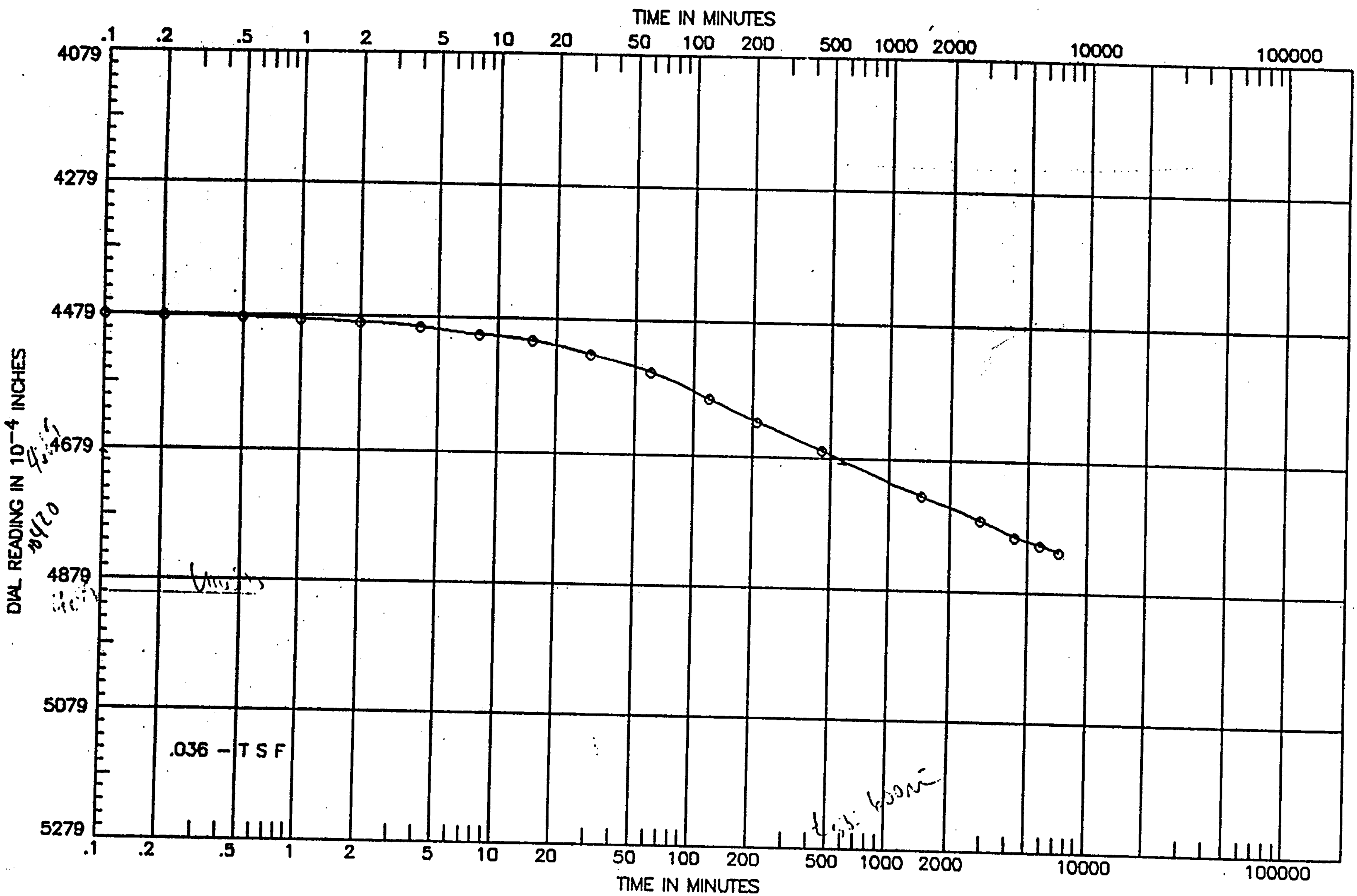


PROJECT	TOLEDO HARBOR		
BORING		SAMPLE NO.	LM2-3
DEPTH/ELEV		DATE	06 AUG 93

CONSOLIDATION TEST TIME CURVES

LABORATORY USAE WES – STF/GL

SHEET 3 OF 8



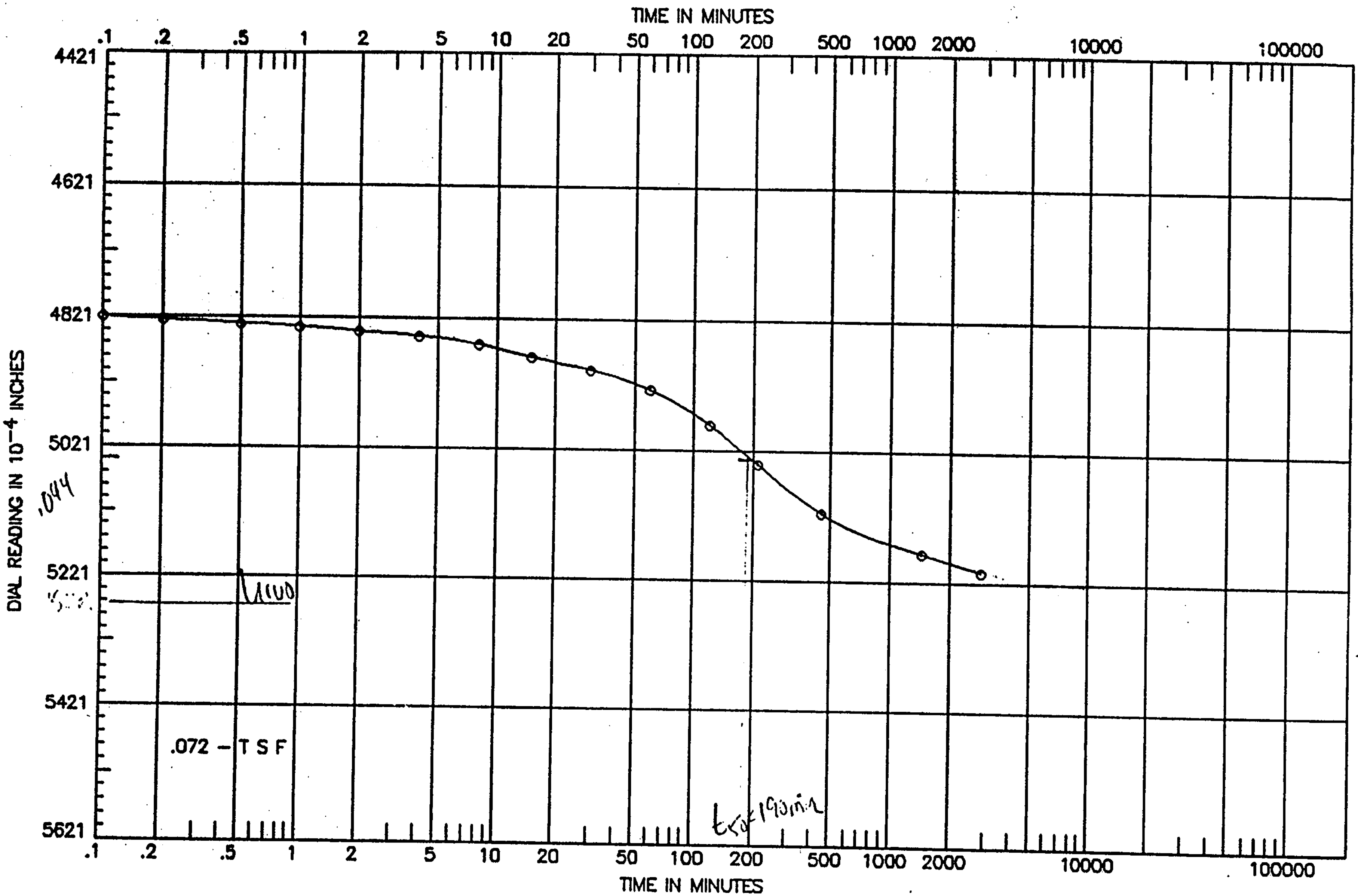
PROJECT TOLEDO HARBOR	
BORING	SAMPLE NO. LM2-3
DEPTH/ELEV	DATE 06 AUG 93

SHEET 4 OF 8

CONSOLIDATION TEST TIME CURVES

LABORATORY USAE WES – STF/GL

(24)



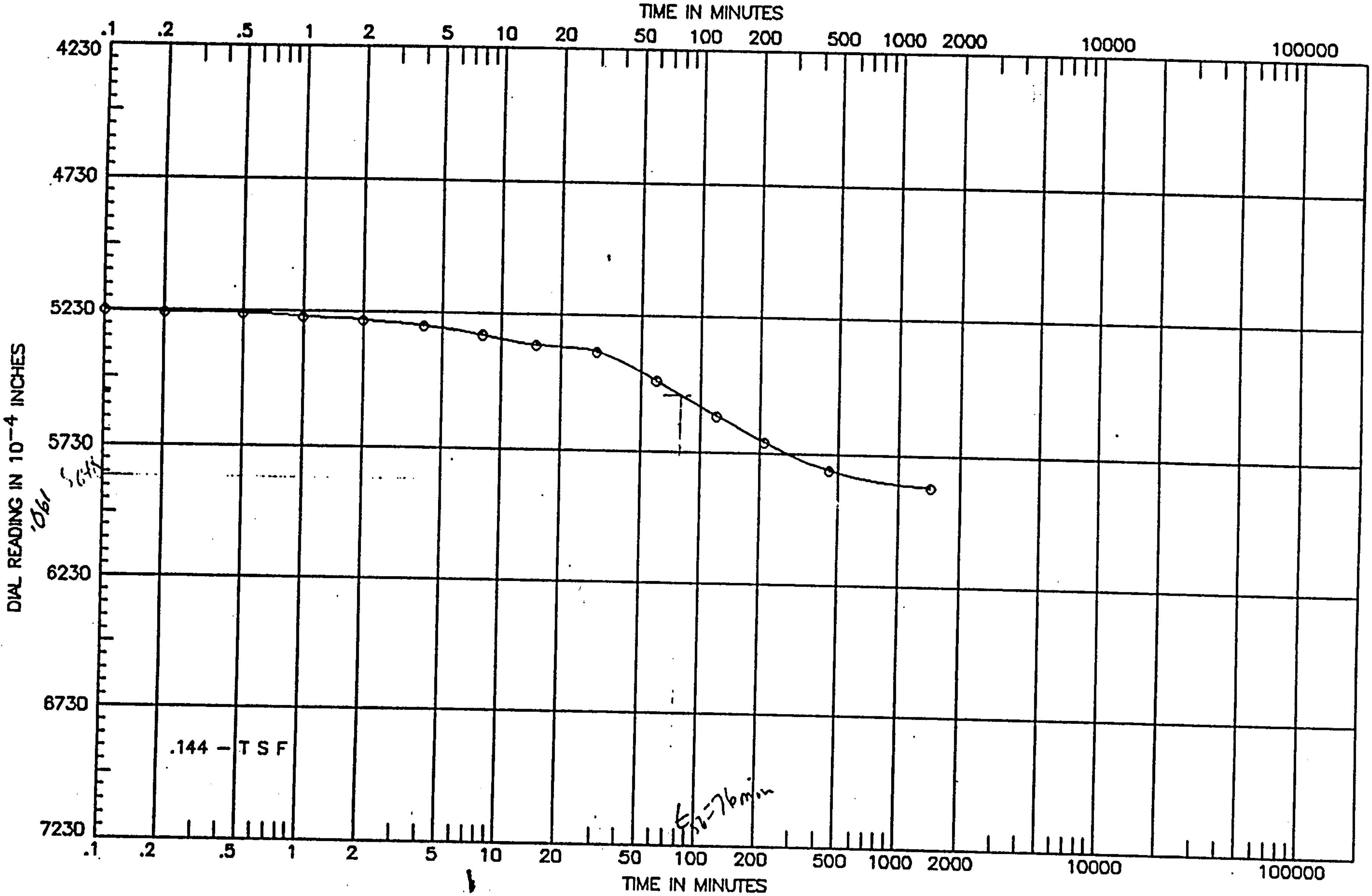
PROJECT TOLEDO HARBOR	
BORING	SAMPLE NO. LM2-3
DEPTH/ELEV	DATE 06 AUG 93

CONSOLIDATION TEST TIME CURVES

LABORATORY USAE WES – STF/GL

SHEET 5 OF 8

(43)

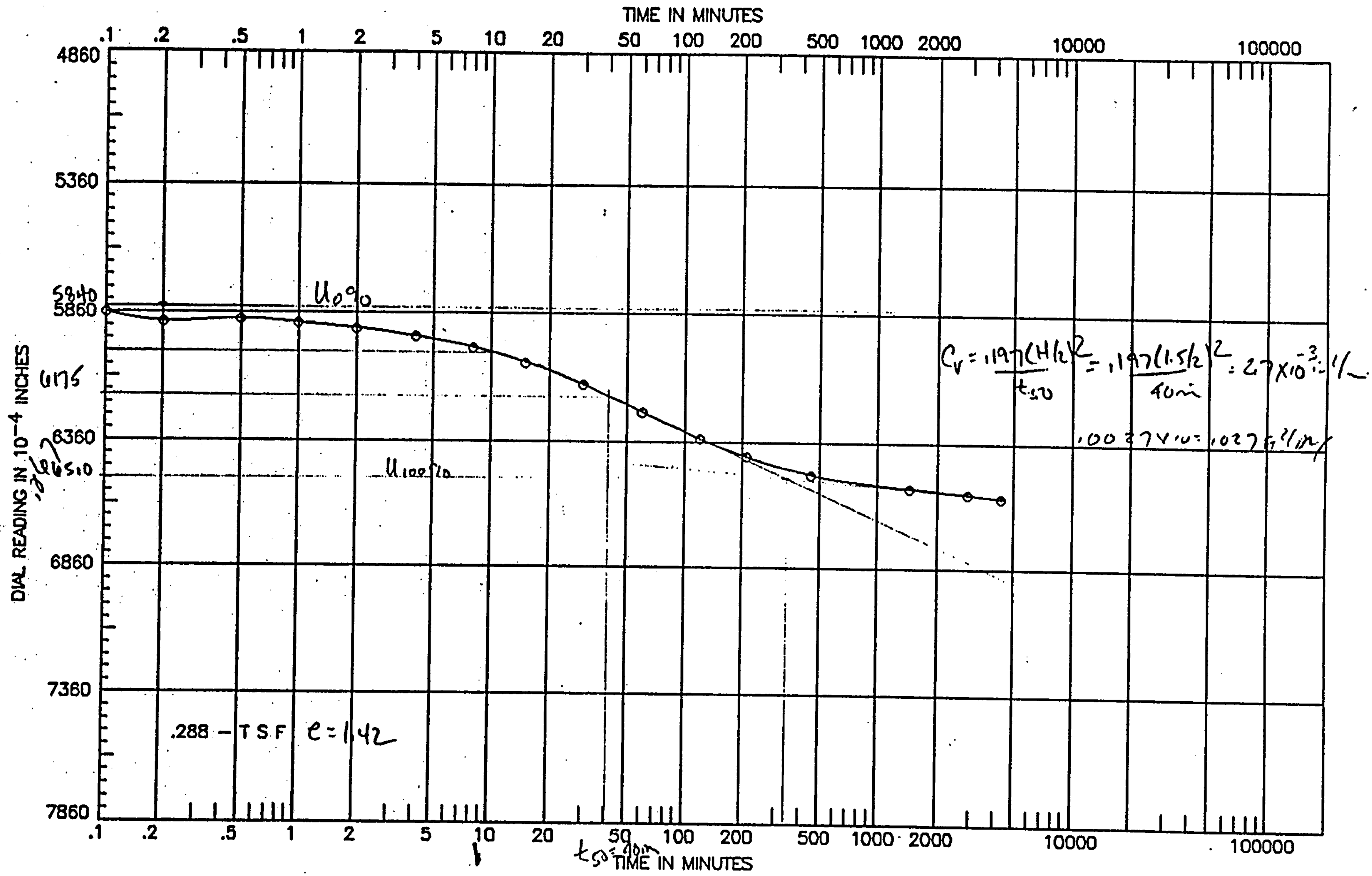


PROJECT	TOLEDO HARBOR
BORING	SAMPLE NO. LM2-3
DEPTH/ELEV	DATE 06 AUG 93

CONSOLIDATION TEST TIME CURVES

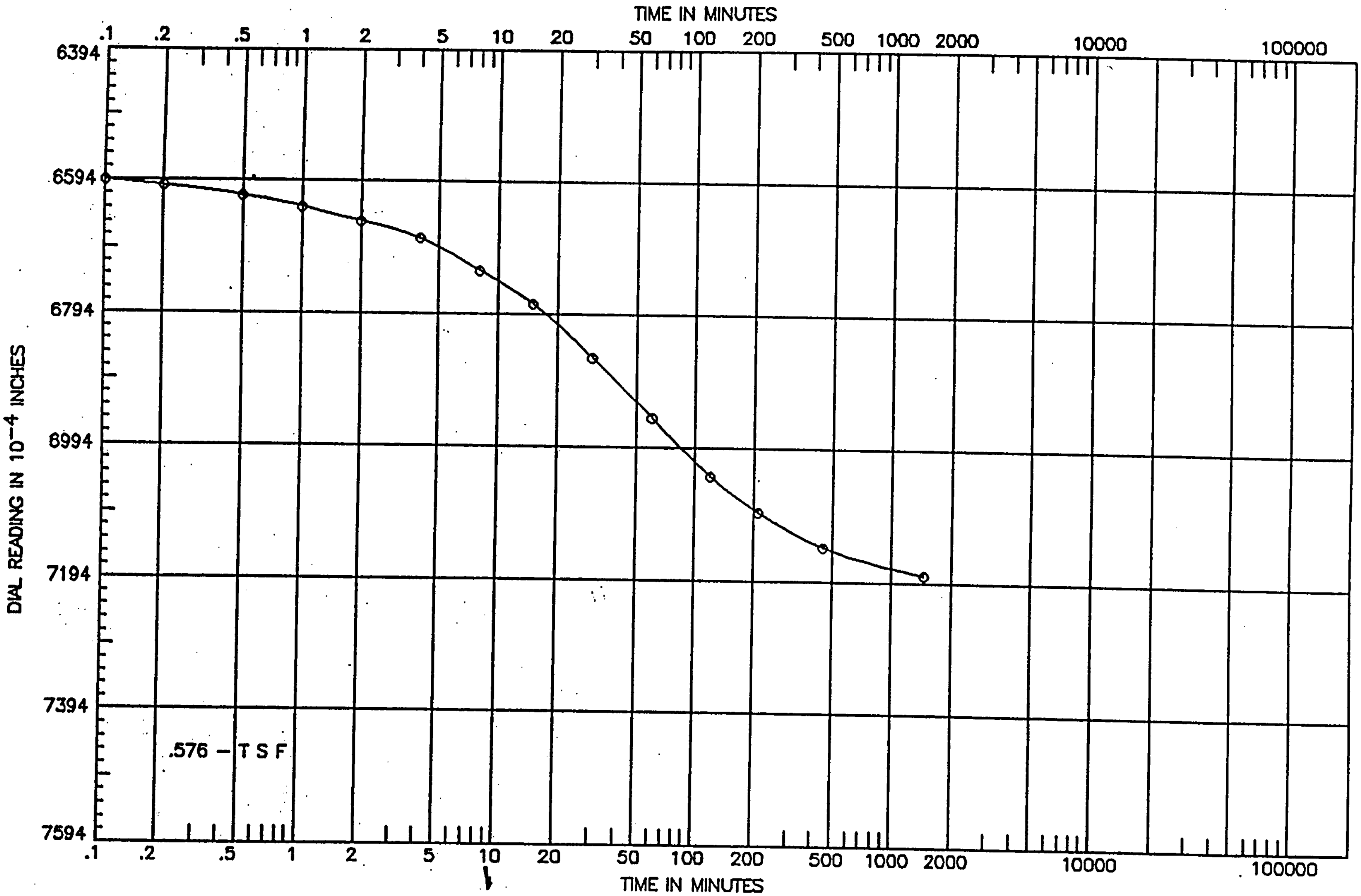
LABORATORY USAE WES – STF/GL

SHEET 8 OF 8



PROJECT TOLEDO HARBOR		CONSOLIDATION TEST TIME CURVES
BORING	SAMPLE NO. LM2-3	LABORATORY USAE WES — STF/GL
DEPTH/ELEV	DATE 06 AUG 93	

SHEET 7 OF 8



(116)

CONSOLIDATION TEST TIME CURVES

LABORATORY USAE WES – STF/GL

PROJECT TOLEDO HARBOR	
BORING	SAMPLE NO. LM2-3
DEPTH/ELEV	DATE 06 AUG 93

SIEVE ANALYSIS

PROJECT: TOLEDO HARBOR
BUFFALO DISTRICT

BORING:
DEPTH:

SAMPLE: LM2-3 DF: MD5793 .DAT
DATE: 11 AUG 93

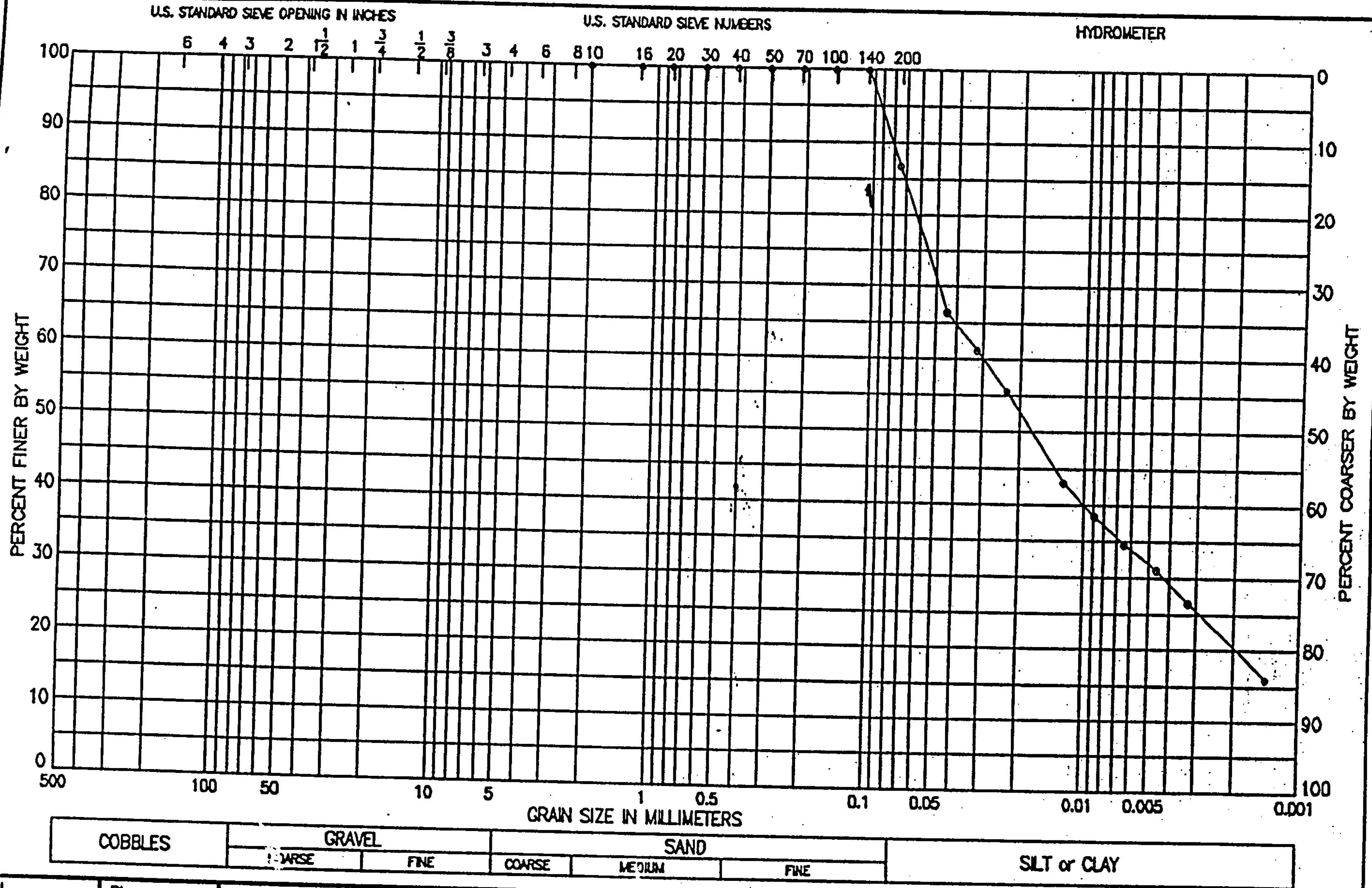
LL: 60 PL: 23 PI: 37 GS: 2.73 WC: .00
CLASSIFICATION: 140
SANDY CLAY (CH), GRAY

TOTAL WEIGHT OF SAMPLE: .0 gms.
PARTIAL WEIGHT AFTER SPLIT: 59.3 gms.

WEIGHTS gm.	SIEVE SIZE or NUMBER	OPENING mm	PERCENT FINER	PERCENT COARSER
.0	No 10	2.000	100.0	.0
.0	No 16	1.180	100.0	.0
.0	No 20	.850	100.0	.0
.0	No 30	.600	100.0	.0
.0	No 40	.425	100.0	.0
.0	No 50	.300	100.0	.0
.0	No 70	.212	100.0	.0
.0	No 100	.150	100.0	.0
.0	No 140	.106	100.0	.0
7.8	No 200	.075	86.8	13.2
HYDROMETER:				
RDGS	TEMP			
25.0	22.5	.0442	66.5	33.5
23.0	22.5	.0320	61.2	38.8
20.9	22.5	.0232	55.6	44.4
16.2	22.5	.0125	43.1	56.9
14.6	22.0	.0090	38.6	61.4
13.0	22.5	.0065	34.6	65.4
11.7	22.5	.0046	31.1	68.9
9.9	23.0	.0033	26.6	73.4
6.3	21.0	.0014	16.0	84.0

PERCENT GRAVEL = .0
PERCENT SAND = 13.2
PERCENT FINES = 86.8

EDE



LL 60	PL 23	PI 37	GS 2.73	NAT W,%	ORG,%

CLASSIFICATION
SANDY CLAY (CH), GRAY

PROJECT TOLEDO HARBOR
BUFFALO DISTRICT

BORING NO.

SAMPLE NO. LM2-3

DEPTH/ELEV

DATE 11 AUG 93

GRADATION CURVE

LABORATORY USAE WES – STF/GL

(XII)

TOLEDO CONFINED DISPOSAL FACILITY

GEOTECHNICAL APPENDIX
DISPOSAL FACILITY CAPACITY ANALYSIS

ATTACHMENT ~~A~~1
Toledo Harbor Sediment Grain Size Analysis ans Atterberg Limits
ARDL, Inc.
Mt. Vernon, Illinois
Tests Performed for Buffalo District

ARDL REPORT NO.: 6256
CORPS OF ENGINEERS - BUFFALO DISTRICT
GRAIN SIZE ANALYSIS DATA PACKAGE
TOLEDO HARBOR SITE

ARDL, Inc.

CHEMISTRY — BIOLOGY — PHYSIOLOGY — ENGINEERING
ENVIRONMENTAL ANALYSIS

P. O. BOX 1566
1801 FOREST STREET
MT. VERNON, ILLINOIS 62864
TELEPHONE (618) 244-3236

GRAIN SIZE ANALYSIS DATA PACKAGE

Corps of Engineers - Buffalo District
Contract No. DACW49-92-D-0008

Date: 12/31/92

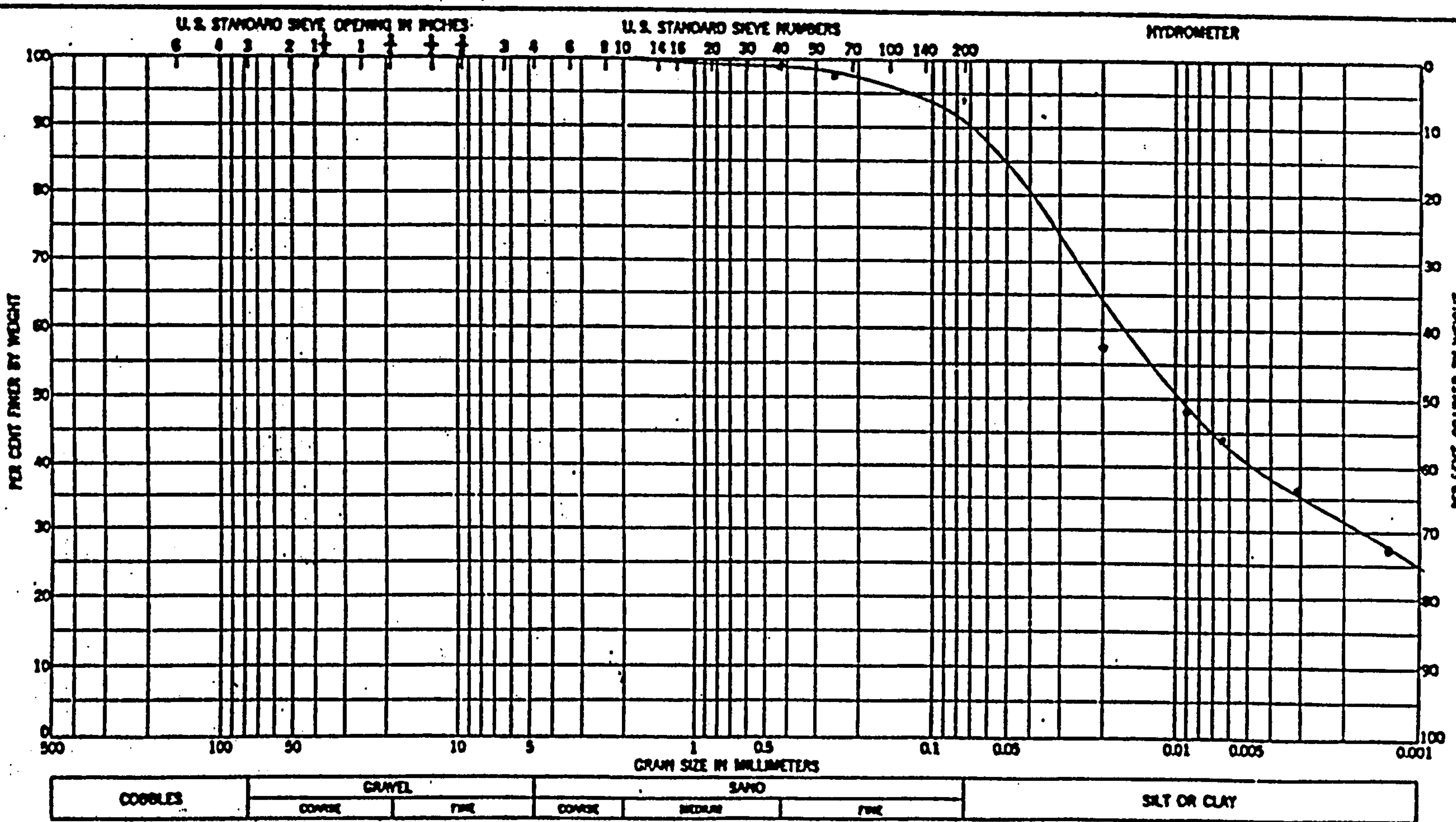
LAB NAME: ARDL, Inc.

SAMPLES RECEIVED AT ARDL: 10/07/92

PROJECT NAME: Toledo Harbor

CUSTOMER ID NUMBER	ARDL ID NUMBER
01/Site 1	6256-1
02/Site 2	6256-2
03/Site 3	6256-3

HOLCOMB FOUNDATION ENGINEERING
P. O. Box 3344
Carbondale, IL 62902-3344



Boring No.	Sample No.	Elev. or Depth	Classification	Nat w %	LL	PL	PI
	6256-1		Clay (CH)	188.8	66.8	34.0	32.8

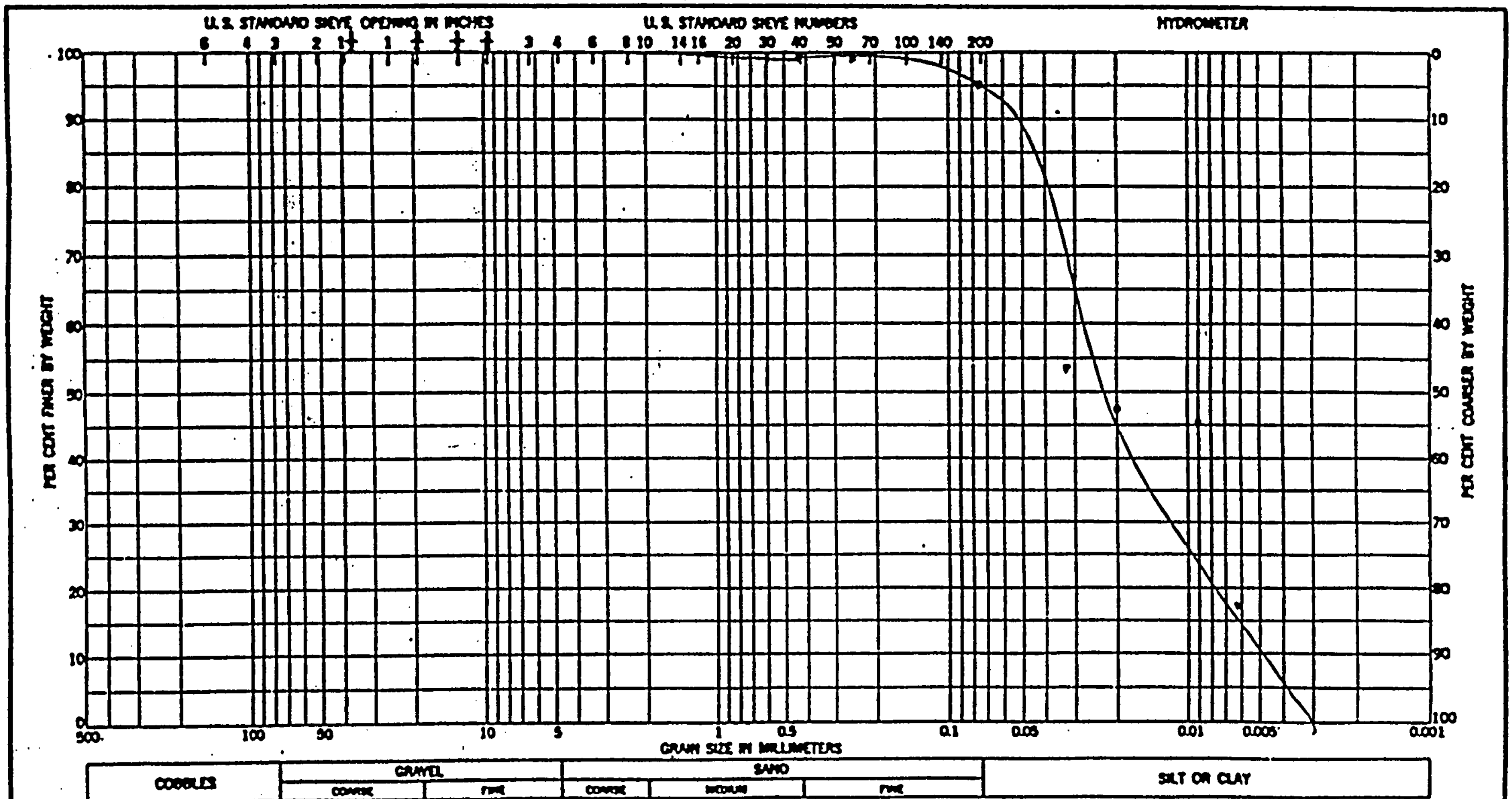
Project Toledo Harbor

File No. H-92020

Date 11-6-92

REPORT OF SOIL ANALYSIS

HOLCOMB FOUNDATION ENGINEERING
P. O. Box 3344
Carbondale, IL 62902-3344



Boring No.	Sample No.	Elev. or Depth	Classification	Nat w %	LL	PL	PI
	6256-2		Silt (MH)	139.3	58.1	32.6	25.5

Project: Toledo Harbor

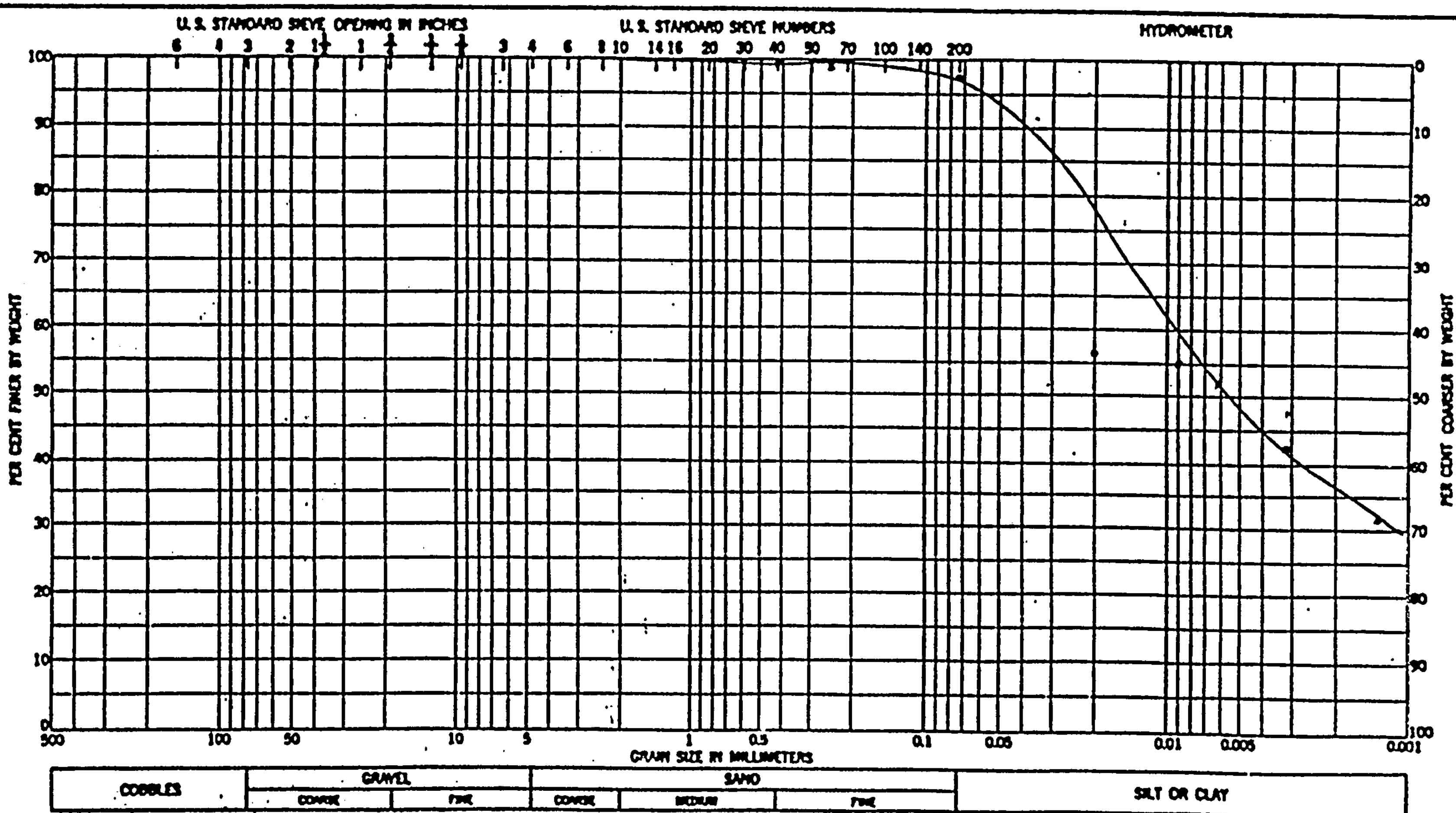
File No. H-92020

Date 11-6-92

REPORT OF SOIL ANALYSIS

(7)

HOLCOMB FOUNDATION ENGINEERING
P. O. Box 3344
Carbondale, IL 62902-3344



Boring No.	Sample No.	Elev. or Depth	Classification	Nat w %	LL	PL	PI
	6256-3		Silt (MH)	175.0	60.6	33.6	27.0

Project Toledo Harbor

File No. H-92020

Date 11-6-92

REPORT OF SOIL ANALYSIS

(72)

TOLEDO CONFINED DISPOSAL FACILITY

GEOTECHNICAL APPENDIX
DISPOSAL FACILITY CAPACITY ANALYSIS

ATTACHMENT A1
Toledo Harbor Sediment Settling Tests
ARDL, Inc.
Mt. Vernon, Illinois
Tests Performed for Buffalo District

ARDL REPORT NO. 6255
CORPS OF ENGINEERS - BUFFALO DISTRICT
TOLEDO HARBOR - COLUMN SETTLING TEST

TARGET INITIAL CONCENTRATION: 150 g/L

		ARDL Sample Number:		6255-1			Customer Number:		Site #1			
				Surface	Solids	Coarse	TSS Values (mg/L)					
	Target	Actual	Elapsed	Water	Interface	Material	Six Foot	Five Foot	Four Foot	Three Foot	Two Foot	One Foot
Date	Time	Time	Time	Height	Height	Height	Port	Port	Port	Port	Port	Port
2/9/93	9:45 AM	9:45 AM	0:00	6'9"	6'9"	6'9"	107000	126000	130000	135000	198000	87900
2/9/93	10:00 AM	10:00 AM	0:15	6'9"	6'9"	6'9"						
2/9/93	10:15 AM	10:15 AM	0:30	6'9"	6'9"	6'8-3/4"						
2/9/93	10:30 AM	10:30 AM	0:45	6'9"	6'9"	6'8-3/4"						
2/9/93	10:45 AM	10:45 AM	1:00	6'9"	6'9"	6'8-11/16"	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
2/9/93	11:00 AM	11:00 AM	1:15	6'9"	6'9"	6'8-1/2"						
2/9/93	11:15 AM	11:15 AM	1:30	6'9"	6'9"	6'8-1/8"						
2/9/93	11:30 AM	11:30 AM	1:45	6'9"	6'9"	6'7-3/4"						
2/9/93	11:45 AM	11:45 AM	2:00	6'9"	6'9"	6'7-5/16"	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
2/9/93	12:15 PM	12:15 PM	2:30	6'9"	6'9"	6'5-13/16"						
2/9/93	12:45 PM	12:45 PM	3:00	6'9"	6'9"	6'3-3/4"						
2/9/93	1:15 PM	1:15 PM	3:30	6'9"	6'9"	6'1-1/8"						
2/9/93	1:45 PM	1:45 PM	4:00	6'9"	6'9"	5'10-1/2"	38300	N.R.	N.R.	N.R.	N.R.	N.R.
2/9/93	2:15 PM	2:15 PM	4:30	6'9"	6'9"	5'7-10/16"						
2/9/93	2:45 PM	2:45 PM	5:00	6'9"	6'9"	5'4-3/4"						
2/9/93	3:15 PM	3:15 PM	5:30	6'9"	6'9"	5'2"						
2/9/93	3:45 PM	3:45 PM	6:00	6'9"	6'9"	4'11-3/4"	2100	10700	N.R.	N.R.	N.R.	N.R.
2/9/93	4:45 PM	4:45 PM	7:00	6'9"	6'9"	4'6-7/16"						
2/9/93	5:45 PM	6:15 PM	8:00	6'8-1/2"	6'8-1/2"	4'3-1/2"						
2/9/93	7:45 PM	8:15 PM	10:00	6'8-1/2"	6'8-1/2"	4'1"						
2/9/93	9:45 PM	10:10 PM	12:00	6'8-1/2"	6'8-1/2"	4'0"	539	918	946	N.R.	N.R.	N.R.
2/10/93	9:45 AM	9:10 PM	1 Day	6'7-1/2"	6'7-1/2"	3'8-1/2"	X	X	X	N.R.	N.R.	N.R.
2/11/93	9:45 AM	8:25 AM	2 Days	6'7-1/2"	6'7-1/2"	3'5-3/4"	195	196	384	N.R.	N.R.	N.R.
2/12/93	9:45 AM	8:52 AM	3 Days	6'7"	6'7"	3'4-1/2"	142	121	192	N.R.	N.R.	N.R.
2/13/93	9:45 AM	8:11 AM	4 Days	6'6-1/2"	6'6-1/2"	3'3"	92.5	60.0	95.8/114	N.R.	N.R.	N.R.
2/15/93	9:45 AM	8:41 AM	6 Days	6'4"	6'4"	2'11"	47.8	172	125	7410/7800	N.R.	N.R.
2/17/93	9:45 AM	8:40 AM	8 Days	6'3"	6'3	2'10"	38.2	44.8	64.6	245	N.R.	N.R.
2/19/93	9:45 AM	9:30 AM	10 Days	6'2-3/4"	6'2-3/4"	2'10"	15.3	21.3	41.9	365	N.R.	N.R.
2/21/93	9:45 AM	10:00 AM	12 Days	6'1"	6'1	2'8"	QNS	16.5/16.5	31.1	100/102	N.R.	N.R.
2/24/93	9:45 AM	9:45 AM	15 Days	6'0"	6'0"	2'7-1/2"	QNS	5.4	6.8	58.5/55.1	N.R.	N.R.
3/1/93	9:45 AM	9:45 AM	20 Days	5'9"	5'9"	2'5-1/4"	QNS	<5.7	18.5	40.5/45.7	N.R.	N.R.
3/6/93	9:45 AM	9:45 AM	25 Days	5'8"	5'8"	2'4"	QNS	<5.7	4.9	10.2/13.7	N.R.	N.R.

QNS = Insufficient sample for analysis. NR = Not required. X = Samples lost in laboratory accident.

TARGET INITIAL CONCENTRATION: 150 g/L

		ARDL Sample Number:		6255-2			Customer Number:		Site #2			
				Surface	Solids	Coarse	TSS Values (mg/L)					
	Target	Actual	Elapsed	Water	Interface	Material	Six Foot	Five Foot	Four Foot	Three Foot	Two Foot	One Foot
Date	Time	Time	Time	Height	Height	Height	Port	Port	Port	Port	Port	Port
4/6/93	10:00 AM	10:20 AM	0:00	7'1"	7'1"	7'1"	143000	142000	131000	124000	121000	113000
4/6/93	10:15 AM	10:35 AM	0:15	7'1"	7'1"	7'1"						
4/6/93	10:30 AM	10:50 AM	0:30	7'1"	7'1"	7'1"						
4/6/93	10:45 AM	11:05 AM	0:45	7'1"	7'1"	7'1"						
4/6/93	11:00 AM	11:20 AM	1:00	7'1"	7'1"	7'1"	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
4/6/93	11:15 AM	11:35 AM	1:15	7'1"	7'1"	7'0"						
4/6/93	11:30 AM	11:50 AM	1:30	7'1"	7'1"	7'0"						
4/6/93	11:45 AM	12:05 PM	1:45	7'1"	7'1"	6'11"						
4/6/93	12:00 PM	12:20 PM	2:00	7'1"	7'1"	6'9-1/4"	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
4/6/93	12:30 PM	12:50 PM	2:30	7'1"	7'1"	6'7-1/4"						
4/6/93	1:00 PM	1:20 PM	3:00	7'1"	7'1"	7'4"						
4/6/93	1:30 PM	1:50 PM	3:30	7'1"	7'1"	6'2-1/4"						
4/6/93	2:00 PM	2:20 PM	4:00	7'1"	7'1"	5'11"	712	N.R.	N.R.	N.R.	N.R.	N.R.
4/6/93	2:30 PM	2:50 PM	4:30	7'0"	7'0"	5'9-1/4"						
4/6/93	3:00 PM	3:20 PM	5:00	6'11-1/2"	6'11-1/2"	5'6-1/2"						
4/6/93	3:30 PM	3:50 PM	5:30	6'11-1/4"	6'11-1/4"	5'4"						
4/6/93	4:00 PM	4:20 PM	6:00	6'10-1/2"	6'10-1/2"	5'1/2"	326	613	N.R.	N.R.	N.R.	N.R.
4/6/93	5:00 PM	5:20 PM	7:00	6'9-1/2"	6'9-1/2"	4'9-1/2"						
4/6/93	6:00 PM	6:20 PM	8:00	6'9-1/2"	6'9-1/2"	4'7-1/4"						
4/6/93	8:00 PM	8:20 PM	10:00	6'9-1/2"	6'9-1/2"	4'9-1/2"						
4/6/93	10:00 PM	10:20 PM	12:00	6'9-1/2"	6'9-1/2"	4'4-1/4"	209	333	N.R.	N.R.	N.R.	N.R.
4/7/93	10:00 AM	10:40 AM	1 Day	6'8"	6'8"	4'1"	191/175	234/245	1500/1350	N.R.	N.R.	N.R.
4/8/93	10:00 AM	10:20 AM	2 Days	6'6-1/2"	6'6-1/2"	3'10-1/4"	119/100	166/186	238	N.R.	N.R.	N.R.
4/9/93	10:00 AM	11:00 AM	3 Days	6'4"	6'4"	3'9"	104/103	122/142	191/170	N.R.	N.R.	N.R.
4/10/93	10:00 AM	9:46 AM	4 Days	6'4"	6'4"	3'8"	105/98	100/104	165/166	N.R.	N.R.	N.R.
4/12/93	10:00 AM	8:10 AM	6 Days	6'2"	6'2"	3'6-1/4"	QNS	76.0/86	102/89	N.R.	N.R.	N.R.
4/14/93	10:00 AM	8:10 AM	8 Days	6'1-1/2"	6'1-1/2"	3'4-1/2"	QNS	87.0	99/106	N.R.	N.R.	N.R.
4/16/93	10:00 AM	10:40 AM	10 Days	6'1"	6'1"	3'3"	QNS	69.0/64	110/120	N.R.	N.R.	N.R.
4/18/93	10:00 AM	10:20 AM	12 Days	6'0"	6'0"	3'2-1/2"	QNS	39.8	57.8	72.6	N.R.	N.R.
4/21/93	10:00 AM	2:15 AM	15 Days	5'10-1/4"	5'10-1/4"	3'2-1/2"	QNS	51.0	58/52	123/123	N.R.	N.R.
4/26/93	10:00 AM	10:30 AM	20 Days	5'11"	5'11"	3'2-1/2"	QNS	31.0/32.2	37.2/31.0	96.0/104	N.R.	N.R.
5/1/93	10:00 AM	10:25 AM	25 Days	5'9-1/2"	5'9-1/2"	3'2-1/2"	QNS	30.0/34.7	28.9/25.6	119/117	N.R.	N.R.
5/6/93	10:00 AM	10:35 AM	30 Days	3'8"	3'8"	3'2-1/2"	QNS	14.1/17.0	21.1/20.5	32.6/31.5	N.R.	N.R.

QNS = Insufficient sample for analysis.

NR = Not required.

INITIAL TARGET CONCENTRATION: 150 g/L

		ARDL Sample Number:		6255-3				Customer Number:		Site #3	
				Surface	Solids	Coarse	TSS Values (mg/L)				
	Target	Actual	Elapsed	Water	Interface	Material	Six Foot	Five Foot	Four Foot	Three Foot	Two Foot	One Foot
Date	Time	Time	Time	Height	Height	Height	Port	Port	Port	Port	Port	Port
6/25/93	10:30 AM	10:30 AM	0:00	7'0"	7'0"	7'0"	67200	63400	71200	71600	91000	123000
6/25/93	10:45 AM	10:45 AM	0:15	7'0"	7'0"	6'11-1/4"						
6/25/93	11:00 AM	11:00 AM	0:30	7'0"	7'0"	6'10-5/16"						
6/25/93	11:15 AM	11:15 AM	0:45	7'0"	7'0"	6'9-1/4"						
6/25/93	11:30 AM	11:30 AM	1:00	7'0"	7'0"	6'8-3/16"	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
6/25/93	11:45 AM	11:45 AM	1:15	7'0"	7'0"	6'7-3/16"						
6/25/93	12:00 PM	12:00 PM	1:30	7'0"	7'0"	6'6-1/8"						
6/25/93	12:15 PM	12:15 PM	1:45	7'0"	7'0"	6'5"						
6/25/93	12:30 PM	12:30 PM	2:00	7'0"	7'0"	6'3-3/16"	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
6/25/93	1:00 PM	1:00 PM	2:30	7'0"	7'0"	6'1"	5300/5230					
6/25/93	1:30 PM	1:33 PM	3:00	7'0"	7'0"	5'10-3/4"						
6/25/93	2:00 PM	2:00 PM	3:30	7'0"	7'0"	5'8-5/16"						
6/25/93	2:30 PM	2:30 PM	4:00	7'0"	7'0"	5'5-13/16"	N.S.	N.R.	N.R.	N.R.	N.R.	N.R.
6/25/93	3:00 PM	4:00 PM	4:30	7'0"	7'0"	5'3-3/16"						
6/25/93	3:30 PM	3:30 PM	5:00	7'0"	7'0"	5'7/16"						
6/25/93	4:00 PM	4:00 PM	5:30	7'0"	7'0"	4'9-5/8"						
6/25/93	4:30 PM	4:30 PM	6:00	6'11-1/2"	6'11-1/2"	4'6-7/8"	899000	818	N.R.	N.R.	N.R.	N.R.
6/25/93	5:30 PM	5:30 PM	7:00	6'11"	6'11"	4'1-1/2"						
6/25/93	6:30 PM	6:35 PM	8:00	6'11"	6'11"	3'9-1/2"						
6/25/93	8:30 PM	8:35 PM	10:00	6'11"	6'11"	3'5-1/2"						
6/25/93	10:30 PM	10:30 PM	12:00	6'11"	6'11"	3'4-1/2"	543	659	503	N.R.	N.R.	N.R.
6/26/93	10:30 AM	11:15 AM	1 Day	6'10-1/4"	6'10-1/4"	3'1"	339	343	480	4300/3840	N.R.	N.R.
6/27/93	10:30 AM	11:10 AM	2 Days	6'9-1/2"	6'9-1/2"	3'0"	215	215/292	259	460/447	N.R.	N.R.
6/28/93	10:30 AM	3:19 AM	3 Days	6'8-1/2"	6'8-1/2"	2'8"	199	166/174	234	374	N.R.	N.R.
6/29/93	10:30 AM	10:10 AM	4 Days	6'6-3/4"	6'6-3/4"	2'5-3/4"	67.0	98.0	180	162/155	N.R.	N.R.
7/1/93	10:30 AM	9:30 AM	6 Days	6'6-3/4"	6'6-3/4"	2'6-1/2"	93.6/82.0	89.2/86.8	104/96.0	122/119	N.R.	N.R.
7/3/93	10:30 AM	2:15 AM	8 Days	6'5-3/4"	6'5-3/4"	2'5"	X	X	X	X	N.R.	N.R.
7/5/93	10:30 AM	3:40 PM	10 Days	6'4-3/4"	6'4-3/4"	2'4"	X	X	X	X	N.R.	N.R.
7/7/93	10:30 AM	11:50 AM	12 Days	6'4"	6'4"	2'2-3/4"	17.6/14.4	16.8/20.5	24.7/25.9	30.0/30.3	4730	N.R.
7/10/93	10:30 AM	12:15 PM	15 Days	6'2"	6'2"	2'2"	QNS	10.7/<14.7	15.2/19.8	11.7/14.8	58.3/76.8	N.R.
7/15/93	10:30 AM	12:10 PM	20 Days	5'1"	5'1"	2'1-1/2"	QNS	<40	26.0/22.0	36.0/30.0	28.0/32.0	N.R.

NS = No sample taken. NR = Not required. QNS = Insufficient sample for analysis. X = Samples lost in laboratory accident.

TABLE OF CONTENTS

Table of Contents Cont.

1 General

In order to obtain the maximum storage volumes from confined disposal facilities, the design and construction of these facilities must account for the long-term increase in storage capacity resulting from compression of the dredged fill and the effective management of these facilities. The dredged fill compresses due to three natural processes: sedimentation, consolidation, and desiccation. Sedimentation is a relatively short term process, whereas consolidation and desiccation are long term processes. The design of the containment area for sedimentation is presented in the original design analysis. In the original design analysis, the long term increase in capacity was determined using non-rigorous empirical volume reduction factors. In this appendix the long term increase in capacity is based upon a more rigorous mathematical computation which considers consolidation and desiccation of dredged material. Since this computation requires the solution of an extensive set of mathematical equations, a computer model was used to determine the long term increase in storage capacity. This computer model is described in more detail in *Section A4* of this appendix.

2 WES Study On Consolidation

2.1 General

The Waterways Experiment Station (WES) performed a geotechnical study for the Buffalo District which evaluated the consolidation potential for Cell 1 of the Toledo Confined Disposal Facility (Ref. 6).

2.2 Objectives of the WES Study

The WES geotechnical study was done to obtain sufficient site-specific information on the engineering properties of Cell 1 to be used in deciding on the proper course of action regarding Cell 1 capacity enhancement, if any.

2.3 Field Work

Field tests were performed and instrumentation installed in April 1994 by a combined Buffalo District/WES crew. The field tests included in situ vane shear measurements made in three locations each at two separate sites in Cell 1, varying in depth below ground surface from less than 3 feet to just over 18 feet. A pneumatic piezometer was installed into each of the 6 holes after the vane shear tests were completed and soil samples were taken. Also, additional soil samples, including moderately disturbed block samples taken from test pits excavated at 3 sites within Cell 1, were recovered and stored for transport in plastic pails. All field work was done by manual effort, without any drill rig or other mechanized means (including the vane shear apparatus), except for the test pits excavated by backhoe.. The soil samples were sealed and taken to the WES lab for index and oedometer (consolidation) testing. The piezometers were monitored for several weeks by Toledo Projects Office staff until it became evident that the readings were stable.

2.4 Lab Testing

Samples recovered from the piezometer borings and backhoe-excavated test pits were tested at WES for natural moisture content, Atterberg limits, and grain size. Four oedometer tests were performed on the block samples to provide consolidation test information. The index and consolidation test results and the vane shear measurements were used to estimate consolidation potential in Cell 1 for several considered scenarios/technologies to enhance consolidation settlement in.

2.5 Evaluation of Alternative Technologies for Consolidation Enhancement

Three alternatives were evaluated for consolidation enhancement in Cell 1: Strip drains, electro-osmosis, and trenching. The strip drain method, employed very successfully at Craney Island CDF in Virginia, was judged to be cost ineffective for this Toledo Harbor project, due to the relatively small size of the site and its unfavorable geology. A bench scale electro-osmosis test was performed on soil sampled from Cell 1. This technology was also found to be cost ineffective for this application, due to the electrochemical character of the Cell 1 soil and the tremendous energy costs required. It was concluded that the only potentially viable method that might enhance consolidation to even a modest degree is dike management with trenching and positive drainage. For complete details of this evaluation, see Ref. 6.

Figure 1. Plan of Ohio Demo Dike, Toledo CDF Cell #1

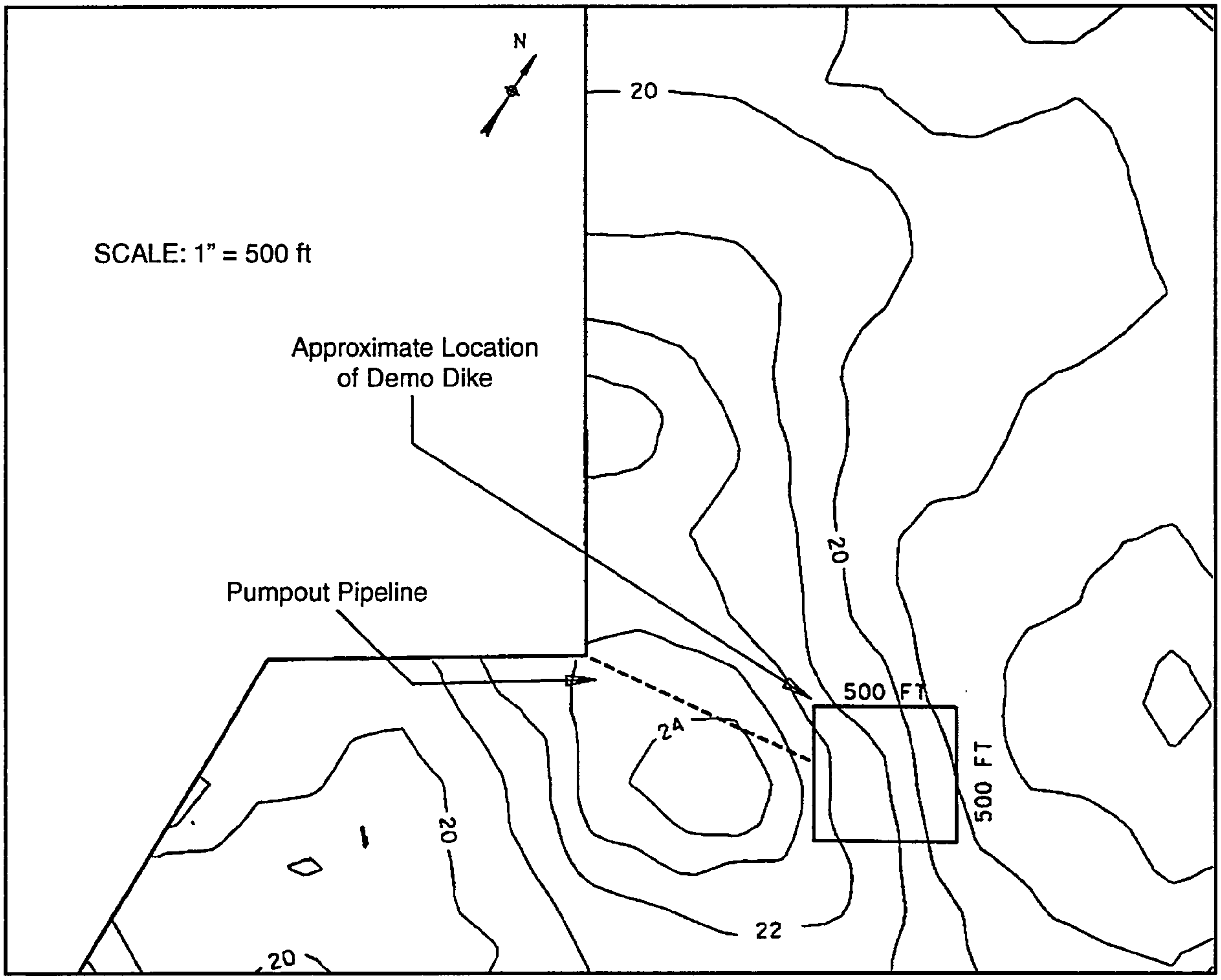
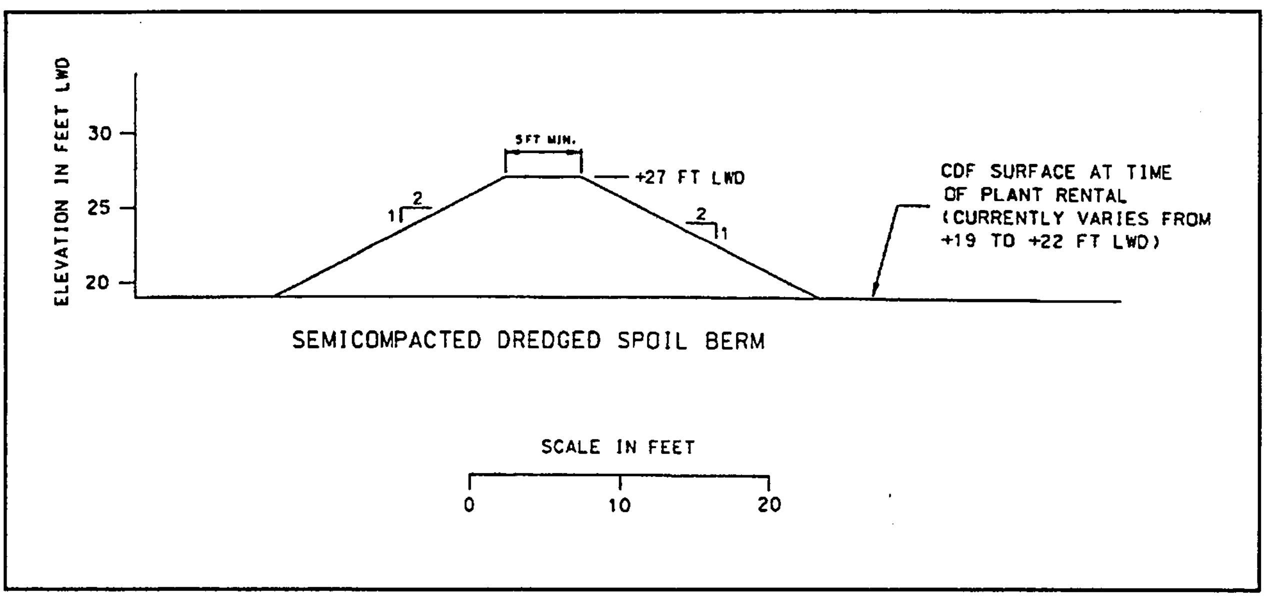


Figure 2. Toledo CDF Plant Rental Contract Typical Berm Section



3 Dike Management - DEMOS Programs

3.1 General

Two demonstration programs were conducted and documented in Cell 1, as discussed below, to attempt to verify certain conditions within the existing CDF. They are summarized in the following sections.

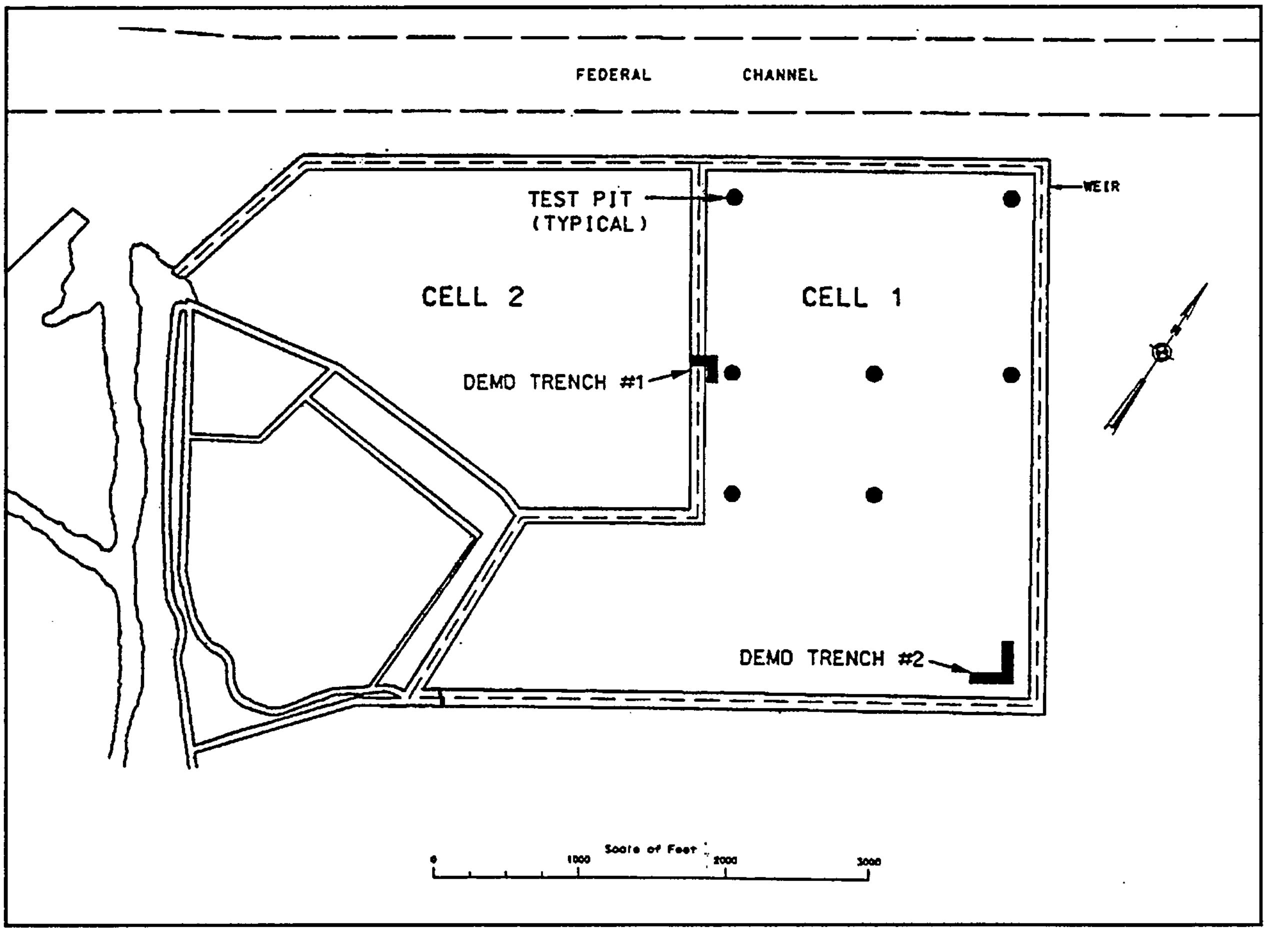
3.2 Cell 1 Dike Raising Demo

A 500' by 500' raised demo berm was constructed in June, 1995 for the primary purpose of determining the feasibility of raising the existing dike using borrow material from Cell 1 and conventional construction equipment. Refer to Figure A1 for the plan of this berm and Figure A2 for the crossection. This demo berm was constructed over an approximate 2 week period by plant rental contract (a CAT 225 tracked hydraulic excavator and.an 850 Case dozer). A total of 7,000 - 10,000 cubic yards of existing dredged material was incorporated into this berm. Since the excavator dug down below grade on both sides of the berm to get to the borrow material, some of the net height achieved (9 feet maximum) was due to downcutting. No special placement/compaction methods were employed. Compaction was achieved by trafficking the dozer over the berm. An outlet channel was cut into the berm and fresh dredged material was pumped into the demo berm from an ongoing Corps Maumee River cutter-head dredging project through a 16 inch diameter pipeline. Failure of the berm occurred once, at a corner, due to overtopping. Otherwise, the raised demo berm performed without incident over the duration of the demo experiment (a few weeks). The slopes (2H:1V) held up and the only visible change to the demo berm was some infilling with the fresh dredged material. Besides satisfying the primary purpose for this demo (i.e., evaluate constructibility and performance), the berm served as a useful baffle for an extended period of time after the demo experiment was finished, which sufficiently slowed the material pumped into the enclosure and redirected its flow to permit some further effective placement of dredged material in Cell 1 (which was essentially full). Therefore, this demo proved to be successful and useful beyond its original purposes.

3.3 Cell 1 Trenching Demo

A trenching demo program was conducted as a direct result of the WES capacity study summarized above. By excavating a series of shallow trenches into the existing Cell 1 materials, the viability of adopting this method for increasing Cell 1 capacity by induced consolidation settlement of the dredged material could be evaluated. Two separate trenching demos were conducted on opposite sides of Cell 1, as shown by *Figure 1*. This work was done by conventional plant rental equipment under a plant rental contract. In the first case (trenching demo no. 1), a deep trench was dug into the dredged material. It remained virtually dry for several months. It was concluded that the dredged material at that location was mature and very little free water existed in the soil. Therefore, this demo provided no additional information about trenching/drainage/enhanced consolidation settlement except the trench was easy to excavate and little water drained into the trench.The second trenching demo was done near the eastern corner of Cell 1 (see *Figure 3*). This consisted of an L-shaped trench dug into the dike surface just behind the existing dike wall/perimeter road. No external drainage was provided to remove the water from the trenches, due to the scope of this demo project. Unlike the other demo area, these trenches filled up with water shortly after the trenches were dug and remained so for the duration of the experiment. Again, these trenches were easily excavated by conventional equipment. A third part of the trenching demo consisted of a series of seven test pits, dug at various locations in Cell 1 (see *Figure 3*). These were dug by backhoe to maximum depth (about 15 feet) and maintained as monitoring points within Cell 1. Based on observations of the water levels in these test holes, it was concluded that the water levels in Cell 1 vary significantly from one location to another within the dike. This may be due to variation in soil gradation (i.e., coarser sediments near former pumpout locations which might bring in water more readily or carry it away more readily). Also, the maturity of the dredged material varies across Cell 1. Some spots, such as at trenching demo No. 1, are very mature and almost devoid of water. Others, such as trenching demo No. 2, are full of water and may have much fresher dredged material at the surface. The Toledo Projects Office monitored water levels in the test trenches over much of the fall of 1996. It became apparent that only portions of Cell 1 might be candidates for trenching to drain water and enhance consolidation settlement, while others had very little potential. It was decided that at best this method, if fully applied with optimal trench spacing and depth, as well as positive drainage outside of Cell 1, might induce some minor consolidation settlement, enough perhaps, if the trenching was deep enough, to add up to an additional year of capacity . Also, providing effective drainage at depth (15-20 feet) would be expensive, as would the deep trenching. One result of the trenching demos, common to all areas, is the production of large quantities of excavated material, which would

Figure 3. Plan of Demo Trenches and Test Pits in Cell 1



add considerable cost to the project for relocation of this material away from the trenches. Therefore, the trenching demo was discontinued after the fall of 1996, considered to be an ineffective means to enhance capacity, based on the demo programs. However, shallow trenching of the dike surface in conjunction with filling operations might provide useful benefits as a dike management measure, by improving short-term drainage off the dike surface, enhancing crust formation, and improving dredging efficiency in the dike, subject to effluent quality criteria. Shallow trenching, therefore, is rejected as a meaningful capacity enhancement measure for this old cell. However, trenching could prove beneficial as a technique to manage the remaining storage capacity of a new cell, when the new cell has been filled to a capacity above the maximum lake water level.

3.4 Conclusions

It appears that Cell 1 has been reasonably well managed over its life. The Toledo Projects Office has employed such techniques as effective surface drainage, strategic repositioning of pumpout disposal locations, and use of temporary baffles and low internal berms (excavated by dragline) over the past decade which have significantly increased the capacity of Cell 1. This was verified by the WES study of 1995 (Ref. 6). In addition, Toledo Projects Office has performed frequent topographic surveys to assess remaining Cell 1 capacity and guide subsequent dredged material placement. These surveys revealed that over a three year period 1.4 million cubic yards of storage capacity had been restored in Cell 1 due to a combination of many factors (the trenching demo techniques employed, the raised dike demo, beneficial reuse of the dredged material, repositioning the dredge outlet pipe to various locations within the dike (taking advantage of available space), and manipulating weir boards to facilitate drainage and enhance capacity). Since there is limited remaining capacity in Cell 1, in the long term, future dike management must be focused on Cell 2 and any future raised dike configuration. These methods are applicable to Cell 2 and a raised CDF scheme. If the dike is managed from the earliest practical time in its design life until it is filled to capacity, some beneficial additional capacity might be realized. Proper dike management is more important today than in the past, since CDFs are more difficult to site and more costly to build.

4 Dessication/Capacity Computer Model

4.1 General

Engineering properties of both the dredged material and the foundation soils beneath Toledo CDF were needed as input to a computer model which predicts settlement of the dredged material over time. Climatological data for the Toledo area was also required as input. This computer model, used to determine the long term increase in storage capacity in Cell 2, is discussed below.

The computer model entitled "Primary Consolidation and Desiccation of Dredged Fill (PCDDF89)", was originally developed by CPT Kenneth W. Cargill at the US Army Engineer Waterways Experiment Station (WES) under the name "PCDDF". The latest version, PCDDF89, was updated in 1989 by Dr. Arsalan Ghahramani under the supervision of Dr. Timothy D. Stark at San Diego State University under a contract with WES.

PCDDF89 simulates the consolidation and desiccation processes in fine-grained soils using the finite strain theory of consolidation and an empirical desiccation model. Settlement is calculated for each compressible layer within the dike disposal area, and a cumulative settlement for each subsequent dredge fill layer and compressible foundation layer is determined. Additional layers of dredged fill may be added at any time. A total of 25 types of dredged fill and 25 foundation layer types may be analyzed in one simulation.

4.2 Input Data

Data is input into the computer model either by creating a formatted data file or by using an interactive program called "INPCDDF". This interactive program provides data input menu screens and then automatically creates a formatted data file.

Types of input data required to run a computer simulation consists of (1) foundation material properties (compression properties, specific gravity, permeability); (2) dredged material properties (compression properties, specific gravity, permeability, desiccation properties); (3) incompressible foundation reference elevation, compressible foundation thickness, and initial dredged fill thickness; (4) simulation times; (5) additional fill heights; (6) initial void ratio of dredged material at time of disposal; and (7) climatological data (for desiccation settlement).

The foundation and dredged fill properties are entered once for each material type. An identification number for each material type is assigned by the user during data input for subsequent fill lifts. The material properties entered into the computer model include: void ratio, effective stress (from self weight and oedometer consolidation tests), permeability, and specific gravity.

The reference elevation for the incompressible foundation can use any datum the user specifies. All subsequent compressible foundation, dredge fill heights and dredged fill settlements are referenced to this base elevation. The user also specifies the depth to groundwater in this input data segment. This is the elevation below which desiccation of the dredged fill cannot occur. For Toledo Dike this elevation is low water datum for Lake Erie (El. 568.6 IGLD, 1955). The actual saturated zone in the CDF is probably much higher, due to the low permeability of the dredged material and the regular addition of large amounts of water to the dike during dredged material placement.

The user also specifies the simulation times, additional dredge fill lift thickness, dredged fill material type identification number, month, and number of time periods (days) that desiccation starts for the new dredged fill layer. The simulation times represent the time at which settlement is desired and the time at which additional dredged fill lifts are applied.

Finally, the user inputs climatological and dredge fill desiccation property data. Climatological data includes amounts of average monthly rainfall (inches) and average monthly evaporation (inches). The desiccation properties of the dredged fill includes the void ratio at the saturation limit (at the start of second stage drying) and the void ratio at desiccation limit (where evaporation effectively ceases).

4.3 Output Data

Output from the computer model is sent directly to the computer screen and to an output data file. The output provides the following information: (1) current foundation material information (void ratios, effective stress, excess pore water pressures); (2) current dredged fill material information (void ratios, effective stress, excess pore water pressures); (3) degree of consolidation for each simulation print time; (4) consolidation settlement for each simulation print time; (5) desiccation settlement for each simulation print time; and (6) current surface dredged fill elevation for each simulation print time. An optional graphic plot option can be selected by the user to plot the dredged fill surface elevations as a function of time. The dredged fill surface elevation as a function of time information provides a method to track the filling rate of the disposal facility which can be used for planning purposes.

5 Dredged Material Properties

5.1 General

Material properties needed to estimate the increase in volume of the dredged material after it has been removed from its in situ (river) conditions and volume reduction after it has been placed into the containment facility are as follows: (1) specific gravity, (2) in situ void ratio, (3) in situ water content, (4) in situ unit weight, (5) in situ solids concentration, (6) column settling properties, (7) self weight consolidation properties, (8) consolidation (oedometer), (9) Atterberg limits, (10) desiccation limit, and (11) shrinkage limit. The following paragraphs discuss these material properties and the design values used in the consolidation computer model. Other design parameters used in the computer model include weather data (i.e., average monthly rainfall and evaporation) and foundation material properties. The weather data is discussed in Section A8 and the foundation material properties are found in Section A7.

5.2 In Situ (River) Sediment Properties

Samples from the Maumee River were obtained and tested in 1983, 1986, 1988 and 1993. The samples tested in 1983 (Floyd Brown Associates), 1986 (DePinto, Young, and Terry), and 1988 were obtained at various locations along the Maumee River and Lake Erie access channel between mile 0 to river mile 7 and from mile 0 to lake mile 16. These samples were tested for physical characteristics (particle size analysis, bulk density, and moisture content). The test results are summarized in Table A1 with the actual test results are presented in Attachment A1. The test results revealed that the Maumee River sediments consisted of clay, silt, and fine sand with the majority of the sediments consisting of fine grained sediments (more than 50% passing the # 200 sieve). On the average, 86% of the total weight passed the #200 sieve.

Table 1. Maumee River Physical Characteristics

Year Tested	Site No.	% Passing #200 Sieve	%Sand
1983	L-3-M	100.0	0.0
1983	L-2-M	73.4	26.6
1983	L-1-M	100.0	0.0
1983	0-M	98.3	1.7
1983	R-1-M	72.7	27.3
1983	R-2-M	98.8	1.2
1983	R-3-M	100.0	0.0
1983	R-4-M	78.4	21.6
1983	R-5-M	60.6	39.4
1983	R-6-M	53.5	46.5
1983	R-7-M	98.8	1.2
1988	L-3-M	92.6	7.4
1988	L-2-M	96.4	3.6
1988	L-1-M	97.9	2.1
1988	0-M	96.9	3.1
1988	R-1-M	82.8	17.2
1988	R-2-M	96.5	3.5
1988	R-3-M	98.0	2.0
1988	R-4-M	80.6	19.4
1988	R-5-M	73.5	26.5
1988	R-6-M	67.7	32.3
1988	R-7-M	81.0	19.0
	AVG =	86.3	13.7

Hydrometer tests were performed by T.P. Associates Inc. in June, 1988 for the Corps of Engineers. Test data reported included wet weights, percent solids, dry weights, and hydrometer density readings. From this data the water content and in situ void ratio of the river sediments can be determined. *Table 2* summarizes the hydrometer test data and the computed water contents and in situ void ratios. The actual test data is presented in *Attachment 1*. The wet weights varied from 99.4 to 100.9 grams, dry weights varied from 29.9 to 59.5 grams, and percent solids varying from 30% to 59.4%. The in situ void ratios of the harbor sediments vary from 1.8 to 5.9 with an average void ratio of 3.8 and the water contents varying from 68.2 percent to 201.5 percent with an average water content of 144 percent.

Table 2. Maumee River Hydrometer Test Results

Wet Weight (g)	% Solids	Dry Weight (g)	Weight Water (g)	Water Content (%)	Void Ratio
100.3	48.3	48.4	51.9	107.2	2.8
100.1	33.2	33.2	66.9	201.5	5.3
100.2	31.0	31.1	69.1	222.2	5.9
100.2	42.2	42.3	57.9	136.9	3.6
100.1	59.4	59.5	40.6	68.2	1.8
100.0	59.4	59.4	40.6	68.4	1.8
100.2	38.5	38.6	61.6	159.6	4.2
100.3	42.2	42.3	58.0	137.1	3.6
99.9	54.0	53.9	46.0	85.3	2.3
100.1	35.0	35.0	65.1	186.0	4.9
100.1	36.3	36.3	63.8	175.8	4.7
99.8	30.0	29.9	69.9	233.8	6.2
100.0	38.2	38.2	61.8	161.8	4.3
100.0	48.8	48.8	51.2	104.9	2.8
100.0	39.3	39.3	60.7	154.5	4.1
100.0	41.7	41.7	58.3	139.8	3.7
101.0	41.7	42.1	58.9	139.9	3.7
99.7	46.2	46.1	53.6	116.3	3.1
100.2	38.9	39.0	61.2	156.9	4.2
101.4	43.3	43.9	57.5	131.0	3.5
100.4	36.9	37.0	63.4	171.4	4.5
99.9	36.6	36.6	63.3	173.0	4.6
100.2	42.3	42.4	57.8	136.3	3.6
99.4	42.3	42.0	57.4	136.7	3.6
100.0	36.8	36.8	63.2	171.7	4.6
99.5	37.0	36.8	62.7	170.4	4.5
100.2	37.6	37.7	62.5	165.8	4.4
100.9	54.7	55.2	45.7	82.8	2.2
100.1	41.5	41.5	58.6	141.2	3.7
100.3	46.6	46.7	53.6	114.8	3.0
100.2	47.6	47.7	52.5	110.1	2.9
			AVG =	**143.9**	**3.8**

Atterberg limits of the river sediments were obtained in 1992 (ARDL Inc.), 1993 (WES), and 1994 (WES). Table A3 summarizes the Atterberg limits tests with the actual test data presented in Attachment A1. Liquid limits vary from 58.1 percent to 93 percent with an average of 75 percent. Plastic limits vary from 21 percent to 47 percent with an average of 32 percent. Plasticity indices vary from 25.5 to 60 with an average of 43.

Table 3. Atterberg Limits Maumee River Samples

Sample No.	LL	PL	PI
6256-1(92)	66.8	34.0	32.8
6256-2(92)	58.1	32.6	25.5
6256-3(92)	60.6	33.6	27.0
LM2-3(93)	60.0	23.0	37.0
LMO-1(93)	89.0	33.0	56.0
RM1-2(93)	88.0	31.0	57.0
C1-1,1(94)	73.0	21.0	52.0
C1-2,1(94)	93.0	33.0	60.0
C1-2,2(94)	75.0	47.0	28.0
C1-3,1(94)	90.0	31.0	59.0
AVG =	**75.4**	**31.9**	**43.4**

5.3 Column Settling Test Data

In September 1993 column settling tests were performed on river sediment samples by ARDL Inc. for the Buffalo District. The settling tests were performed in a plexiglass settling column with an inside diameter of 8 inches and an overall height of 8 feet. The column was sampled at ports positioned at 2, 3, 4, 5, and 6 feet from the bottom of the column. The settling tests were performed at initial suspended solids concentrations of 150 g/l and 400 g/l.

The results of the column settling tests are shown graphically in *Figures 4 thru 6*. The actual test results are presented in *Attachment A1*.

The settling tests were used in the capacity analysis to determine the initial concentration and void ratio of dredged river sediments at the time of disposal into the disposal facility. To determine the concentration of the dredged sediments at the time of disposal a production rate of 7,000 cy/hr was assumed for a hopper dredge. The void ratio at the time of disposal was computed using the following relationship:

$$e_o = \frac{G_s Y_w}{C_d} \qquad \text{(A-1)}$$

where:

e_o = Void ratio

G_s = Specific gravity of solids (2.7)

Y_w= Unit weight of water (1,000 g/l)

Cd = Concentration of dredged material (g/l)

Field studies indicate that for maintenance dredging of fine grained material, the disposal concentration will average about 150 g/l (EM 1110-2-5027). For a dredged volume of 600,000 cy/yr the average amount of time to dredge and dispose of this material into the disposal site is 1,028 hours (85.7 days), which corresponds to a dredged material solids concentration of 434 g/l (See *Figure 1*) and a void ratio of 6.1. Similarly, for a dredged volume of 850,000 cy/yr, the average time to dredge and dispose of this material in the CDF is 1,457 hours with a corresponding solids concentration of 445 g/l and void ratio is 5.96. Finally, for a dredged volume of 400,000 cy/yr, the average time is 600 hours, the corresponding solids concentration is 421 g/l, and the void ratio is 6.29.

Figure 4. Toledo Harbor Settling Tests - Sample No. 6255-1, Co = 150g/l

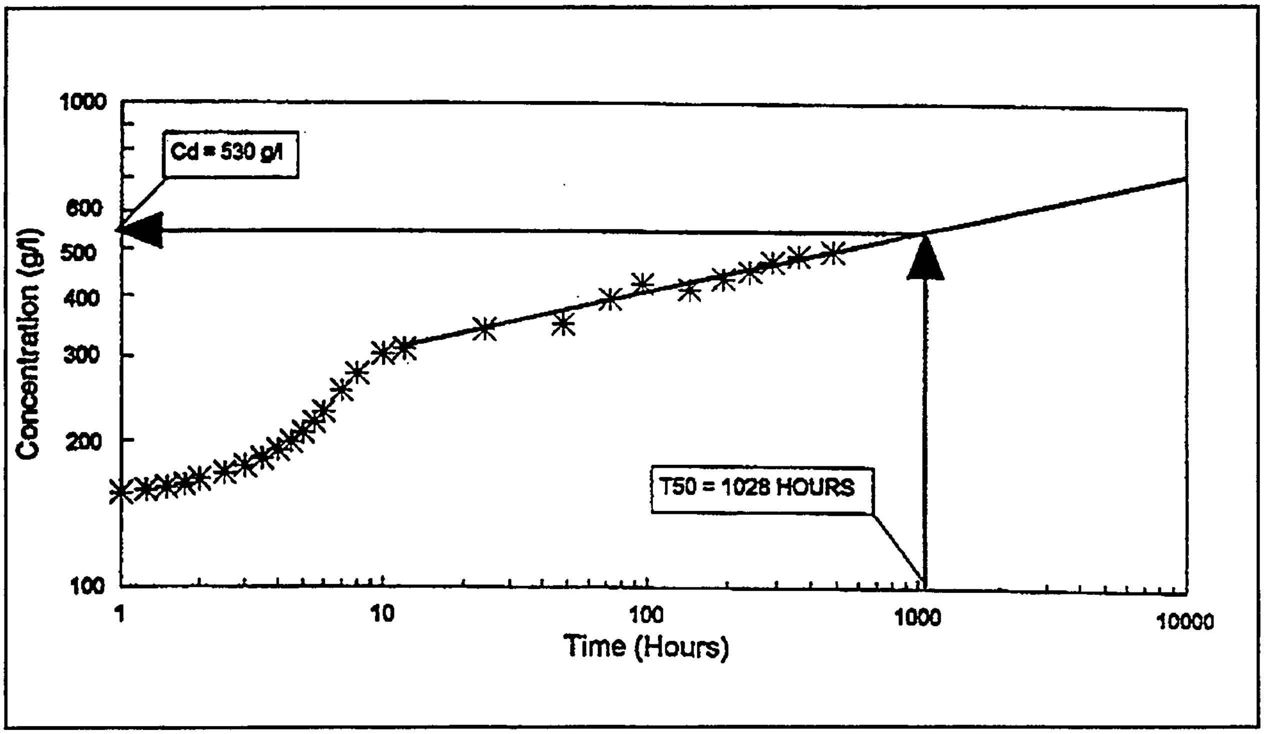


Figure 5. Toledo Harbor Settling Tests - Sample No. 6255-2, Co = 150g/l

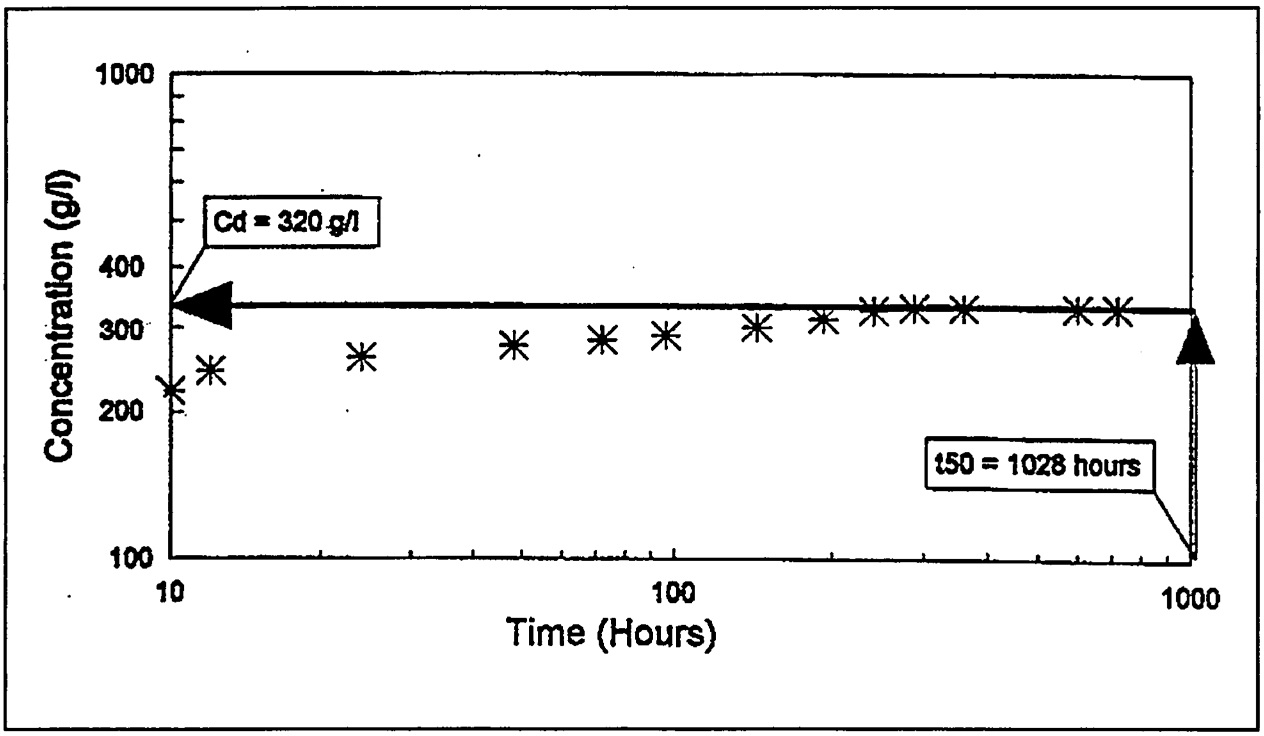


Figure 6. Toledo Harbor Settling Tests - Sample No. 6255-3, Co = 150g/l

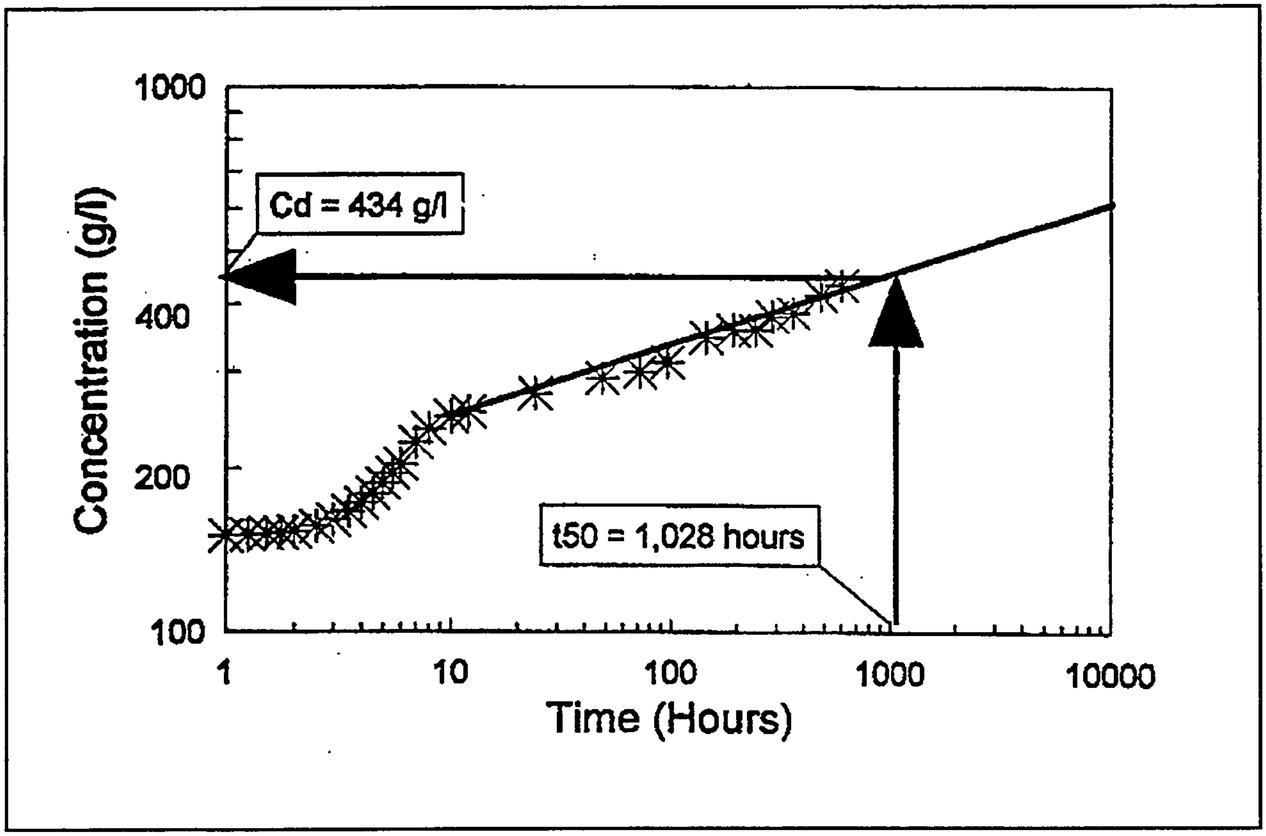
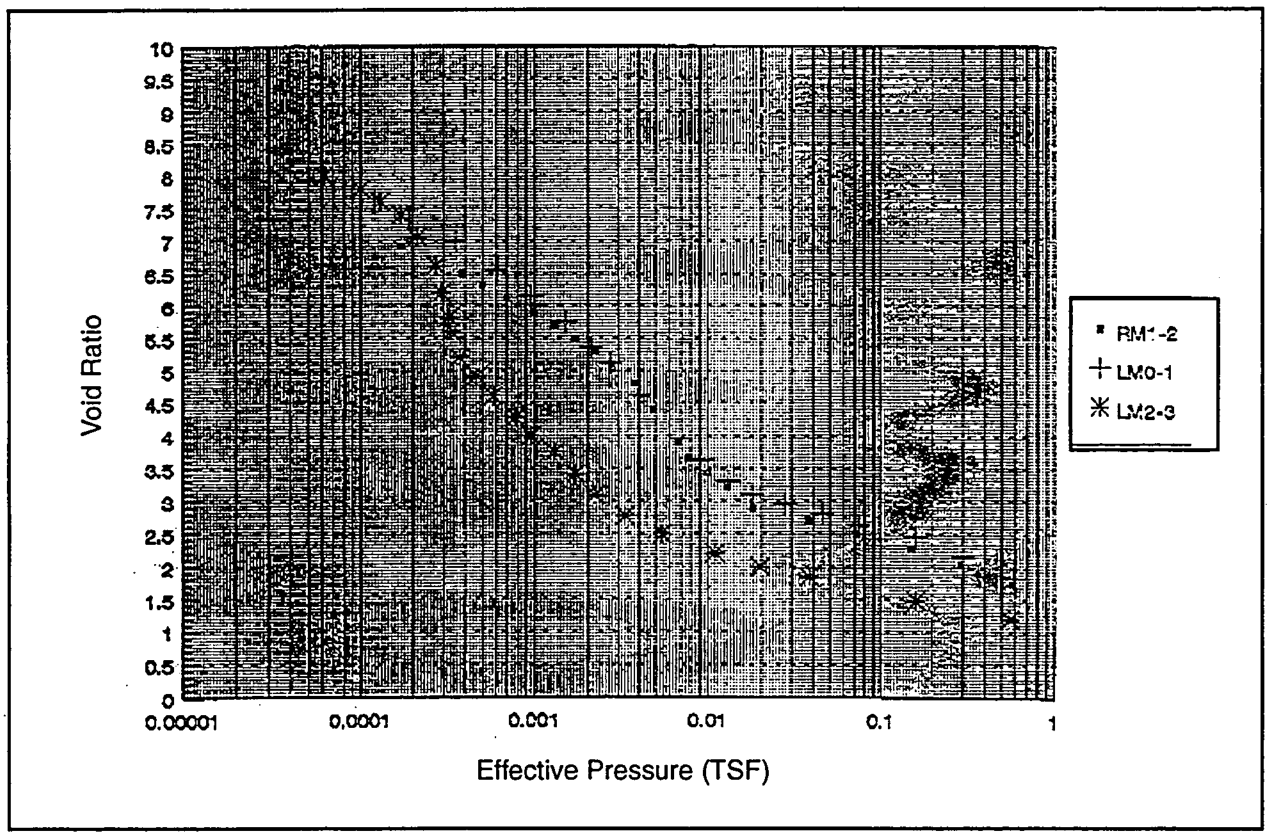


Figure 7. Toledo Harbor Seld-Weight and Oedometer Test Results



5.4 Self-Weight and Oedometer Consolidation Test Results

Self-weight consolidation (i.e., very low levels of applied effective stress) and Oedometer (higher levels of applied effective stress) consolidation tests results were used to determine the consolidation characteristics of the dredged materials after they have been placed into the disposal facility. The self-weight and oedometer consolidation tests were performed in August 1993 by the Waterways Experiment Station for Buffalo District.

Figure 7 presents a graphic plot of the self-weight consolidation and oedometer test results. The actual test results are presented in *Attachment 1*. *Table 4* presents the weighted average self-weight and oedometer consolidation void ratio, effective stress and permeability relationships for the dredged material. These values were used as input into the computer model. The permeability was determined by the following relationship:

$$k = \frac{0.197H^2 Y_w a_v}{(1+e)t_{50}} \qquad \text{(A-2)}$$

where:

k = Permeability (ft/day)

H = Drainage path (1/2 sample height, double drainage)

Y_w= Unit weight of water (62.4 lb/ft^3)

a_v = Coefficient of compressibility (1/lb)

e = Void Ratio

t_{50} = Time to 50% consolidation (days)

Table 4. Dredged Fill Void Ratio, Effective Stress, and Permeability Relationships

Void Ratio	Effective Stress (lbs)	Permeability (ft/day)
8.40	0.00	.18
7.70	0.13	.10
7.25	0.32	.08
6.72	0.60	.04
5.65	1.80	.018
3.65	10.00	.0025
3.05	22.00	.00027
2.70	44.00	.00015
2.42	86.00	.00014
2.00	350.00	.00011
1.60	1200.00	.00009

5.5 Desiccation and Shrinkage Limits

Effective evaporative drying of dredged material leading to the formation of a desiccated crust is a two stage process. The first stage begins when all free water has been decanted or drained from the dredged material surface. During the second stage the dredged material begins to lose saturation, starting with the surface, and develops negative pore water pressures which shrink the material to a hard crust having a much lower permeability and reduced evaporative rates.

The shrinkage limit or saturation limit is the void ratio at which first stage drying ends and the second stage begins. The saturation limit is computed from the following relationship:

$$e_{sl} = \frac{1.8 LL G_S}{100} \qquad \text{(A-3)}$$

where:

e_{SL} = Void ratio at saturation limit

LL = Liquid limit of dredged material (percent)

Gs = Specific gravity of dredged material (2.7)

As discussed in *Section 5.2*, Atterberg limits performed on river channel sediments resulted in liquid limits varying from 58 percent to 93 percent with an average of 75%. Inserting the average liquid limit into the above relationship results in a void ratio of 3.65 for the saturation limit.

The desiccation limit is the void ratio at which second-stage drying effectively ends. At the desiccation limit, evaporation of additional water from the dredged material effectively ceases. What evaporation occurs is limited to excess moisture from rainfall and water forced out of the dredged material due to consolidation. The desiccation limit is obtained from the following relationship:

$$e_{DL} = \frac{1.2 PL G_S}{100} \qquad \text{(A-4)}$$

where:

e_{DL} = Void ratio at desiccation limit

PL = Plastic limit of dredged material (percent)

Gs = Specific gravity of dredge material (2.7)

As discussed in *Section 5.2*, grain size analysis and Atterberg limits performed in the laboratory indicate that dredged material from the river channel consists primarily of plastic, fine grained clay material with plastic limits varying from 21 percent to 47 percent with an average of 32 percent. Inputting the average plastic limit into the above relationship results in a void ratio of 1.04 at the desiccation limit.

Another relationship used to determine the void ratio at the desiccation limit is as follows:

$$e_{DL} = \frac{w G_S}{S} \qquad \text{(A-5)}$$

where:

w = Water content at the desiccation limit (percent)

Gs = Specific gravity of dredge material (2.7)

S = Degree of saturation at desiccation limit (percent)

Haliburton (1978) suggested that the degree of saturation at the desiccation limit is about 80 percent. Since the dredged material is a relatively low permeability, high plasticity clay, it is assumed that the water content at the desiccation limit is about 45 percent. Thus, inputting these values into the above relationship results in a void ratio of 1.52 for the desiccation limit.

6 Foundation Material Properties

6.1 General

The placement of dredged material also imposes a loading on the containment area foundation; therefore, additional settlement and disposal capacity may result from consolidation of compressible foundation soils. The PCCDF89 computer model determines the additional settlement caused by the imposed loads from the dredged material using the foundation material properties input into the computer model. The foundation material types and compression characteristics were obtained from the Geotechnical Design Report for Cell No. 2 (Bowser Morner, 1987) (Ref. 11). A subsurface exploration program was performed in 1986 by Bowser Morner under contract to the Buffalo District for the purpose of obtaining foundation design data. The subsurface explorations revealed that the foundation consisted of about 8.5 feet of very soft organic sandy clay overlying 9 feet of soft lacustrine clay. Underlying the lacustrine clay is about 40 feet of stiff glacial till clay. This information is required to compute the incremental amount of consolidation of the foundation soils, in addition to the consolidation of the overlying dredged material.

6.2 Compression Characteristics and Specific Gravity

Laboratory consolidation tests were performed by Bowser Morner in 1987 on foundation samples obtained in the 1986 subsurface exploration program. Typical consolidation test results defining the compression characteristics of the foundation soils are summarized in *Table 5*.

Table 5. Typical Foundation Compression Characteristics

Void Ratio	Effective Stress (psf)	Permeability (ft/day)
.507	60	.215E-04
.479	1,000	.970E-05
.452	2,000	.230E-05
.415	4,000	.100E-05
.386	8,000	.100E-05
.343	16,000	.600E-06
.306	32,000	.500E-06
.262	64,000	.500E-06

6.3 Depth to Incompressible Foundation

No bedrock was encountered in any of the 1986 borings. However, other geologic studies indicated that bedrock in the study area is generally found at depths of about 100 feet. For this analysis it was assumed that the depth to incompressible foundation is 60 feet below lake bottom (El. 503.6).

7 Climatological Data

7.1 General

Desiccation of dredged material is basically the removal of water by changing the state of the water near the surface from a liquid to a gas. This change of state results primarily from evaporation and transpiration. The loss of water from these processes results in a reduction of void ratio and subsequent volume reduction of the dredged material. The PCDDF90 computer model determines this volume reduction by taking monthly climatological data as input and thru a set of equations determining the change in water content and void ratio of the dredged fill during the desiccation process.

7.2 Evaporation and Rainfall Data

Evaporation is mainly controlled by such variables as radiation heating from the sun, convective heating from the earth, air temperature, ground temperature, relative humidity and wind speed. To determine the evaporation rates in the Toledo, Ohio area historical monthly Class A pan evaporation rates were obtained from NOAA published reports. This data is summarized in *Table 6*.

Table 6. Summary of Monthly Rainfall and Evaporation Potential Toledo, Ohio

Month	Rainfall (inches)	Evaporation (inches)
1	.17	.00
2	.15	.00
3	.22	.00
4	.25	.26
5	.24	.34
6	.29	.41
7	.27	.43
8	.27	.37
9	.21	.27
10	.16	.16
11	.20	.00
12	.22	.00

Other factors which desiccation settlement is dependent upon include: (a) rainfall, (b) water supplied from lower consolidating dredged material, and (c) water from overland flow (i.e., from excess rainfall). Water from lower consolidating layers is obtained from consolidation equations incorporated into the computer model. The historical monthly rainfall data for the Toledo area was obtained from NOAA published reports and is summarized in Table A6. Overland flow in the in the computer model is determined by assuming a drainage efficiency (i.e., 0.5 for poorly drained, 1.0 well drained) for the containment facility. The drainage efficiency is the ratio of overland flow over the rainfall. A drainage efficiency of 1.0 effectively means that all monthly rainfall is removed from the site by surface drainage therefore leaving no rainfall available for evaporation and absorption into the dredge fill.

8 Verification of Computer Model

8.1 General

In order to determine if the computer model PCDDF89 provides a reliable estimate of the capacity of the new Cell 2 CDF and the remaining capacity of the old Cell 1 CDF, a verification analysis was performed. This verification analysis was performed by comparing the computer model estimated dredged fill surface elevations and dredged fill inplace volumes to the actual dredged fill surface elevations and volumes for Cell 1.

8.2 Input Data

The dredged fill compression data input into the computer model for the verification analysis is contained in *Table 4*, the foundation compression data is contained in *Table 5*, and the climatological data was obtained from *Table 6*.

A saturation limit of 3.65 and a desiccation limit of 1.52 (See *Section 5.5*) was inputted into the computer model. Other desiccation parameters used in the computer model are listed in *Table 7* with the rationale for using these values presented in *Section 10.2*

Table 7. Summary of Desiccation Parameters - Cell 1 Verification Analysis

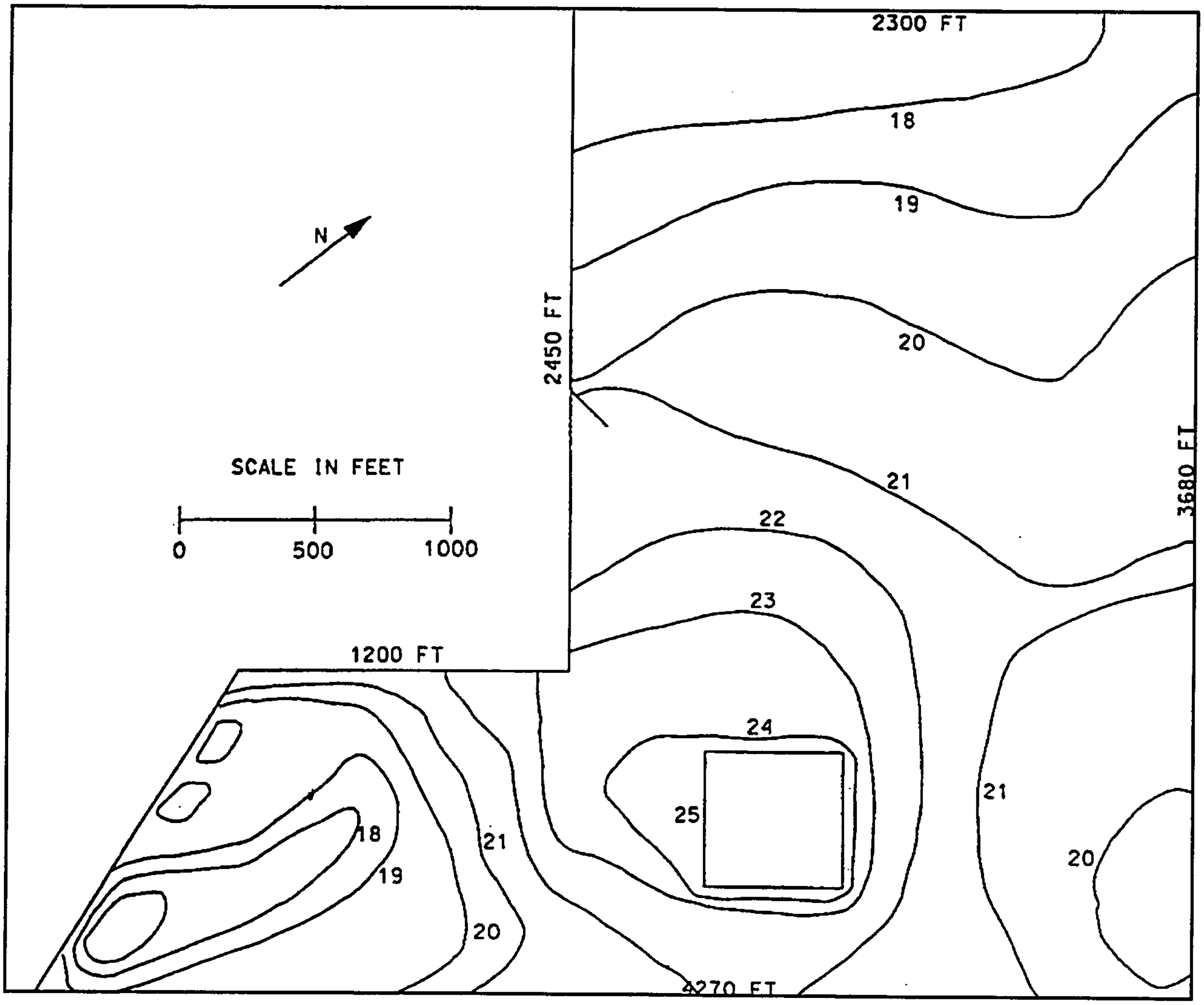
Parameter	Value
Surface drainage efficiency	1.0 (Site managed) 0.5 (Not managed)
Maximum evaporation efficiency	0.50
Saturation at desiccation limit	0.75
Maximum crust thickness (feet)	0.83
Time to desiccation after initial fill (days)	90.0
Month of initial desiccation	7
Elevation of fixed water table (feet)	568.6
Elevation of incompressible foundation	503.6

In addition to the above data, the print times (i.e., time in days at which dredged fill settlement, surface elevations and additional fill lifts are desired) and dredge fill lifts were inputted into the computer model and are summarized in *Table 8*. Historical yearly dredged volumes were used to compute the additional dredged fill lifts. The initial dredged fill void ratio at the time of disposal was obtained using equation A-1. The solids concentration at the time of disposal was obtained from *Figure 6* with t50 obtained from the yearly historical dredged volumes and a production rate of 7,000 cy/day.

Table 8. Summary of Additional Lifts and Print Times for Cell 1 Verification Analysis

Year	Yearly Dredged Volume (cy)	Print Time (days)	Fill Height (feet)	Initial Void Ratio
1976	442,238	0	2.4	8.4
1977	796,944	365	4.1	8.0
1978	1,162,747	730	5.8	7.8
1979	654,530	1095	3.4	8.3
1980	859,893	1460	4.3	8.0
1981	999,592	1825	5.0	8.0
1982	854,949	2190	4.2	8.0
1983	899,939	2555	4.4	7.9
1984	916,244	2920	4.4	7.9
1985	567,487	3285	2.8	8.4
1986	375,244	3650	1.9	8.7
1987	384,645	4015	2 8	8.7
1988	273,952	4380	1.4	8.8
1989	183,026	4745	1 9	9.3
1990	484,145	5110	2.4	8.4
1991	211,270	5475	1.1	8.8
1992	643,494	5840	3.1	8.3
1993	617,528	6205	3 8	8.3
1994	585,992	6570	2.8	8.3
1995	712,043	6935	3.2	7.9
1996	-	7300	-	-

Figure 8. Toledo Diked Disposal Area, Cell 1, Survey Contours, September 1996



8.3 Results of Verification Analysis

Figure 8 shows the most recent elevation contours of the dredged fill in Cell 1 which were obtained in September 1996. The elevation contours vary from a low of +18 feet LWD (El. 586.6) at the northern end of the disposal site to a high of +25 feet LWD (El. 593.6) at the south end of the disposal site. The average dredged fill height is about +20.5 feet LWD (El. 589.1).

Lake bottom surveys (May, 1974) performed prior to the construction of the Cell No.1 disposal facility in 1976 shows that the lake bottom elevation varied from -5.0 feet LWD (El. 563.6) at the north end of the disposal facility to about -3.5 feet LWD (El. 565.1) at the south western end of the disposal facility. Using these preconstruction lake bottom surveys and the present dredged fill elevation contours (Figure A8), the volume of the dredged fill occupying the Cell No.1 disposal facility as of September, 1996 was computed to be 9,521,878 cubic yards.

Results of the computer simulation reveal that the dredged fill at the end of the 1996 dredging season should reach a height of +19.86 feet LWD (El. 588.46) for the case where the disposal facility is well managed and a height of +21.65 feet LWD (El. 590.25) for the case that the disposal facility is not managed. Using an average preconstruction lake bottom elevation of 5.0 feet, the volume of dredged fill occupying the disposal facility predicted by the PCCDF89 computer model for the well managed and without management scenarios is 9,588,179 cubic yards and 10,278,559 cubic yards respectively.

Within the past 10 years some attempt was made by the Toledo projects office to at least partially manage the disposal facility by mounding dredge fill in attempt to increase gravity drainage. Thus, the actual drainage efficiency is probably greater than 0.5 (no management) but less than 1.0 (with management using progressive trenching). Using a drainage efficiency in between these two extreme values in the computer model would produce a dredged volume of 9,933,369 cubic yards. Thus, at most the margin of error between the computer model dredge fill volume projections and the actual volume is 4.32% ([9,933,369 cy - 9,521,878 cy/9,521,878]x 100). It is expected that the drainage efficiency is probably closer to 0.5 (non management) and the actual error is expected to be less than 4%. An acceptable margin of error is 10% thus, since the computer model produces results that have less than 4% error it is concluded that the computer model provides a fairly accurate estimate of the capacity of the existing Cell 1 and the new Cell 2 disposal facilities.

9 Capacity Analysis

9.1 General

The remaining capacity of Cell 1 and the new Cell 2 were determined using the PCCDF89 computer model. The analyses considered two alternative scenarios: (1) with dike management and (2) without dike management. The dike management scenario considers that every year the dredged material crust is effectively well drained by progressive surface trenching. The objective of maintaining a well drained crust is to increase the desiccation settlement and thus increase the capacity of the disposal facility.

9.2 Computer Data Input Options

9.2.1 Dredged Fill and Foundation Compression Properties

The dredged fill and foundation compression properties are contained in *Tables 4 and 5.*

9.2.2 Drainage Efficiency Factor

For a well managed disposal facility an efficiency factor of 1.0 was input into the computer model. For the without dike management scenario, drainage would occur by natural processes without the benefit of trenching. An efficiency factor of 0.5 was input into the computer model for this case.

9.2.3 Desiccation Parameter Options

The amount of water lost during desiccation drying is a function of the evaporation efficiency (CE) of the dredged material. Generally, the maximum drainage efficiency is in the range of 0.5 to 1.0. For this analysis the maximum evaporation efficiency was assumed to be 0.5.

The desiccation settlement during second stage drying is dependent upon the degree of saturation of the dredged material. Since water has been expelled out of the dredged material voids during first stage drying, the degree of saturation during second stage drying is expected to be somewhat less than 100%. Thus, for this analysis the degree of saturation at the desiccation limit was assumed to be 75%.

The maximum depth at which second stage drying can occur is the absolute maximum depth at which second stage desiccation drying can occur. This depth can be obtained by plotting the intersection of the void ratio at the desiccation limit and the depth to the water table (measured in the field). Alternatively the maximum depth can also be obtained by measuring the depth of crack formation in the field. Since this type of information was not available for this analysis a depth of 0.83 feet was assumed to be reasonable based upon values used in other studies.

In this analysis it was assumed that the dredging period started in April. The month at which desiccation was expected to start was selected to be the month in which evaporation is at a maximum and rainfall is at a minimum which according to the historical monthly evaporation and rainfall data (See *Table 6*) is in July. Since was assumed to start in April, the time to desiccation would be 90 days in this case (i.e., 1 April to 1 July).

9.3 Cell 1 Capacity

The crest of Cell dike was built to +23.5 feet LWD (El. 592.1) and allows for 2 feet of freeboard (El. 590.1). Historical dredged fill volumes were used in computing the dredged fill lift heights in the computer simulation (See *Table 8*). *Table 9* shows the results of the PCCDF89 simulation for both scenarios (i.e., with and without dike management).

Table 9. Cell 1 Capacity

Scenario	Time to Reach Capacity (Years)	Year Capacity Reached/Elevation
Historical w/ Dike Management	20	1996/ El. 588.46
Historical w/o Dike Management	20	1996/ El. 590.25

Without dike management Cell 1 should have reached its capacity at the end of the 1996 dredging season (i.e., dredged fill El. 590.25 greater than freeboard fill elevation of 590.1). With dike management Cell 1 would have less than 1 year of capacity left (i.e., dredged fill El. 588.46 less than El. 590.1) assuming that the dredged fill lift height is 3.2 feet/yr (600,000 cy/yr).

Dredged fill survey elevation contours as of September, 1996 show that the dredged fill varies in elevation between +18 feet LWD (El. 586.6) and +24 feet LWD (El. 592.6), with an average elevation of about + 20.5 feet LWD (El. 589.1). Comparing the computer model results to the actual survey information reveals that the actual filling falls in between the results predicted by the model for both dike management and without dike management. Thus, it is apparent that the current disposal practices results in some additional settlement than would otherwise be achieved had such practices not been performed, but does not reach the full potential that can be achieved had the dike been fully managed (i.e., by surface trenching).

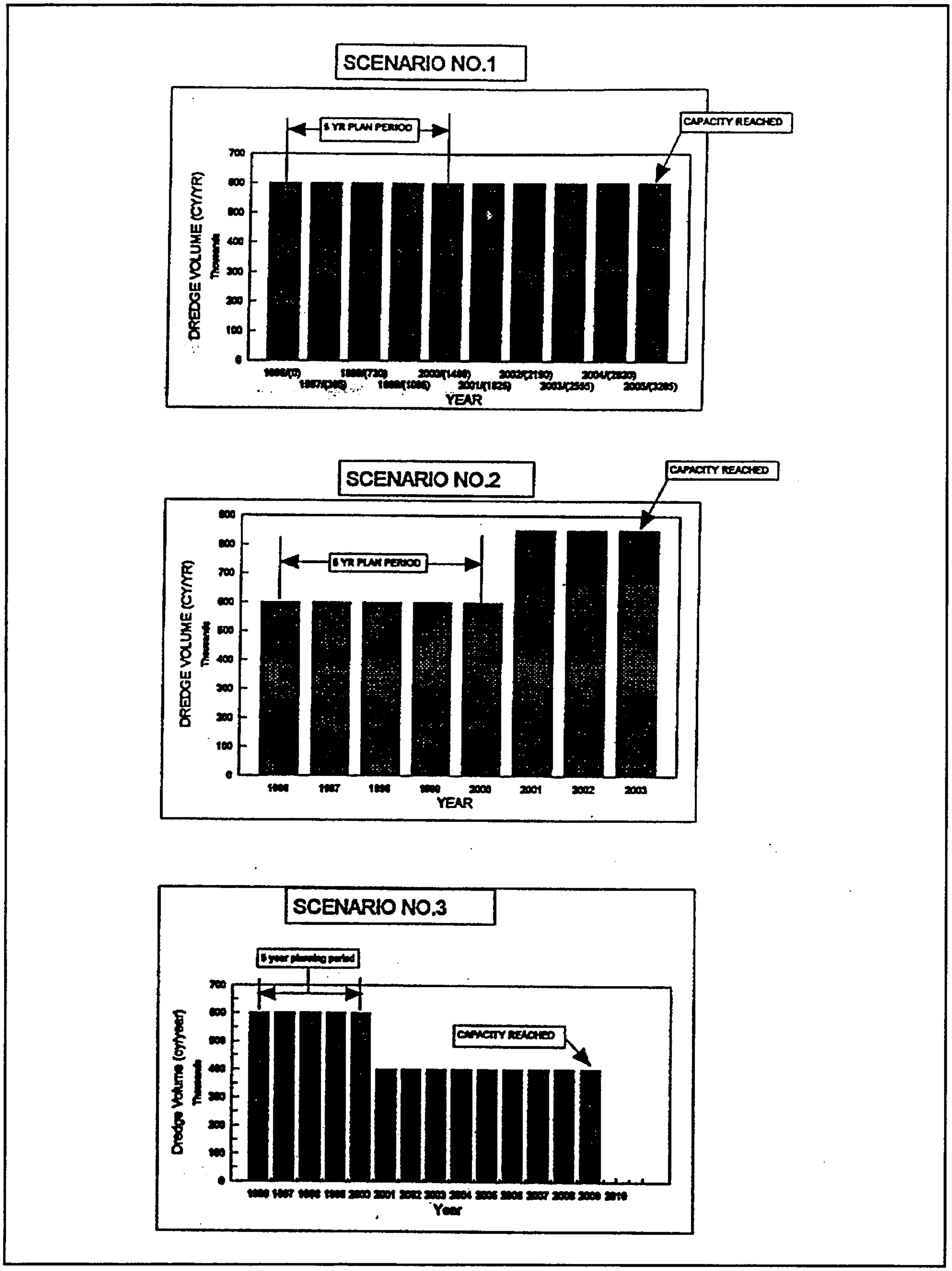
To determine if surface trenching would be beneficial in order to gain additional capacity a computer simulation was performed, assuming a drainage efficiency of 1.0, and allowing the dredged fill to settle for 1 year after the 1996 dredged fill lift has been placed. In this simulation it was assumed that the drainage efficiency prior to the 1996 dredging season was 0.5 (i.e., not managed). Results of this analysis reveal that with surface trenching (i.e., efficiency equal to 1.0) the dredged fill surface would be at 587.84 feet (+ 19.24 feet) and without management (i.e., drainage efficiency equal to 0.5) the dredged fill would be at El.588.02 (+ 19.42 feet). Thus, surface trenching results in a minimal computed increase in capacity of 0 .18 feet in 1 year.

9.4 Cell 2 Capacity

The Cell 2 capacity analysis considered three different scenarios with respect to yearly dredge filling rates for planning purposes and are as follows: (1) follow current disposal practice of placing 600,000 cy/yr (to river mile 2) into Cell 2 during the entire filling period; (2) follow current disposal practice of placing 600,000 cy/year in CDF to year 2,000, then place entire dredging volume of 850,000 cy/yr (to lake mile No.7) in CDF for remaining filling period, (3) follow current disposal practice of placing 600,000 cy/year in CDF to year 2,000, then place 400,00 cy/yr (to river mile No.2) in CDF for remaining filling period. This rate (400,000 cy/yr) represents the worst case for this scenario; an average value for this scenario, taking into account the three different possible options as discussed in the Phase 3 report, is 350,000 cy/yr. In the computer simulation it was assumed that the disposal facility would be managed (i.e. drainage efficiency equal to 1.0).

Figure 9 shows the results of the computer simulation for each of the above scenarios. This figure reveals that for scenario No.1 (i.e. present disposal practice of placing 600,000 cy/yr during entire period) the new CDF would reach its capacity by year 2005 giving a total 10 years of capacity. For scenario No.2 (i.e. present disposal practice of placing 600,000 cy/yr during 5 year planning period to year 2000 then placing entire volume dredged of 850,000 cy/yr in CDF) the CDF would reach its capacity by year 2003 giving a total of 8 years of capacity. For scenario No.3 (i.e. present disposal practice of 600,000 cy/yr during 5 year planning period to year 2000 then placing 400,000 cy/yr in CDF) the CDF would reach its capacity by year 2009 giving a total of 14 years of capacity.

Figure 9.



SCENARIO NO.1
5 YR PLAN PERIOD
CAPACITY REACHED
DREDGE VOLUME (CY/YR)
YEAR
SCENARIO NO.2
CAPACITY REACHED
5 YR PLAN PERIOD
DREDGE VOLUME (CY/YR)
YEAR
SCENARIO NO.3
5 year planning period
CAPACITY REACHED
Dredge Volume (cy/year)
Year

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